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ELECTRICAL CONDUCTORS.

NEAR the close of last year Mr. W. H. Preece, F.R.S., read a paper before the Institution of Civil Engineers on Electrical Conductors. This gave rise to a long, animated, and varied discussion, which occupied two evenings, and in which a number of well known scientists took part. We need scarcely say that if one man more than another is qualified to give an authoritative opinion on the quality of the conductors employed for the transmission of electric currents, that man is Mr. W. H. Preece. In virtue of his connection with the Post Office telegraphs of this country, it stands to reason that he is in a position to acquire more information on this subject than any other engineer of his standing. The eminent Post Office electrician did not bring forward any theoretical considerations, but actual facts, gained by years of experience of the behaviour of every kind of electrical conductor. Professor Hughes, on the strength of the fact that the German and French Governments had laid down some 15,000 and 7,000 miles of underground wire respectively, and that overhead wires were prohibited in Berlin and Paris, believed that the same thing would be accomplished here. Mr. Preece had just previously remarked that Germany and France were only now doing what had been done in this country 25 years ago. The main wires between London, Birmingham, Liverpool, Manchester, Leeds, and all the wires to the cables on the South Coast were then placed underground, but, after sufficient experience of their use, it was found necessary to take them up again. Mr. Preece expects to find the same result taking place, sooner or later, in the two countries previously mentioned, but on this point we feel inclined to dissent from him, as a vast amount of experience has been gained since the period he mentions, and the causes of failure which existed in those days can now be avoided.

Overhead wires are certainly more efficient than those which are laid underground, although their cost of maintenance is far greater; still, we entirely endorse Mr. Preece's opinion that it is absurd to try to force electricians to do that which is commercially wrong and practically foolish, because an outcry, more imaginary than real, if statistics go to prove anything, has been raised on the dangers of overhead wires. During the last 30 years 400,000 persons have been accidentally killed in the United Kingdom, and of this number two accidents only can be traced to telegraph wires. In the face of these facts can overhead wires be said to endanger the lives of the population of great cities?

In the discussion on the compound steel-copper wire now being freely used in America, several gentlemen expressed doubts as to whether the two metals would draw uniformly down, but Mr. Frederick Smith observed that it was the custom amongst wire-drawers to draw wire coated with tin, and both were reduced at the same time without the tin being removed by contact with the draw-plate. Mr. Smith, therefore, appears to be right in his supposition that copper would bear the same kind of treatment.

For aerial lines Mr. Preece concludes that copper, or alloys of copper, are in many instances destined to supplant iron, which has hitherto occupied the field. *Apropos* of the subject, the latest addition to the list of electrical conductors is that brought forward by the British Spiral Telephone Wire Syndicate. To this we alluded in a note (ELECTRICAL REVIEW, Feb. 9th), and we now observe that a report on this peculiar wire has been made by Mr. Frank Lumley, manager and engineer to the National Telephone Company, Dundee. This gentleman states that in the experiments made by him with the spiral wire on a line extending over four miles, the voice seems to be sharper and clearer than on other wires of the same length, and he thinks the spiral wire is a better transmitter of the human voice than the other wires now in use. The lowest whisper and the ticking of a watch can be heard with the utmost distinctness. The wire is No. 13 gauge, and weighs 110 lb. to the mile, against 220 lb. of the ordinary No. 11 iron wire generally in use for telegraphic and telephonic purposes. Its lightness makes it much easier to manipulate, the cost of erection will thus be reduced as against the No. 11, and the public safety much increased.

It appears probable from Mr. Lumley's statement that the spiral wire had been specially erected and tested immediately afterwards. It seems also evident that "the other wires now in use" had been up for some time past. We therefore believe that the superior results attained, or imagined, by Mr. Lumley, can be reproduced on an ordinary wire of the same weight and conductivity, put up under similar conditions. In other words, the spiral wire was probably better insulated than those before in use. One of the authorities of the United States Patent Office remarked that this wire is either "a new feature in electrical science, or a fallacy." One of its chief features was said to be its property of "killing induction," but we see no mention of this in Mr. Lumley's report, and until we get results, either from Mr. Preece or from some one with his experience, we shall prefer to regard the spiral wire from the "fallacy" point of view, and to believe that the wire manufacturers in this country will still hold their own.

LIGHTNING CONDUCTORS.*

THE testing of lightning conductors should comprise—(1) that of the conductor, (2) that of the communication with the earth.

The testing of the conductivity of the conductor, which should have a very low electrical resistance, is very delicate, for it may happen that in consequence of oxidation, or from other reasons, the section of the conductor is reduced in some parts to very small

* *Annales Télégraphiques.*—Extract from a Report of the Committee of Improvement of the Postal and Telegraphic Administration.

dimensions, whilst the electrical tests show no appreciable diminution of conductivity. It is certain, moreover, as M. Helmholtz remarked at the last meeting of the *Congrès des Electriciens*, that the continuity of a conductor might be completely interrupted at one point without destroying the efficiency of the conductor as a preservative against lightning, whilst a fine wire connecting two distant parts of the principal conductor might present a perfect conductivity without offering sufficient capacity for the atmospheric electricity of a storm.

In any case there is no doubt that it is indispensable that the branches of a lightning conductor and their continuity be tested with care from time to time, as is done annually with the lightning conductors on military edifices. As for the frequent trials of continuity, these may be easily made by means of a battery and galvanometer, as will be shown farther on.

The good communication with the earth, which is at least as important, can only be accurately measured by means of two other earth wires, completely independent of the first, and embedded in the soil at a distance sufficient to give perfect diffusion of the electric fluid at each point, and to prevent the passage of electricity directly through the earth which separates them. By means of three galvanometrical experiments we may have the sum of the resistances of these communications taken two by two, and deduce from it the value of each. If x y and z represent these resistances, a b and c the values found for the sums $x + y$, $x + z$, and $y + z$, we have :—

$$x = \frac{a + b - c}{2},\ y = \frac{a + c - b}{2},\ z = \frac{b + c - a}{2}.$$

This experiment, which is very delicate, and in which we must take into account the polarisation of the electrodes, evidently cannot be entrusted to inexperienced persons.

For the lightning conductors of Paris, for example, it is generally considered sufficient to plant in the earth, at a short distance from the lightning conductor, a metallic plate, with a surface one decimetre square, and to ascertain that the current passes when this plate is connected with the rod by introducing into the circuit a battery and a galvanometer. The resistance of the two earths thus measured is ordinarily very high ; it often exceeds, it appears, 2 to 300 ohms, which is a very considerable figure, if we consider that in telegraph offices the resistance opposed to the current by the contact with the soil at each post does not reach, in general, 20 or 25 ohms. It seems necessary to fix a maximum for the resistance which we ought to take for the communication of lightning rods with the soil. This maximum seems capable of being fixed at 25 ohms, and when we determine the total resistance by taking two independent earth wires we should not obtain a figure higher than 5 ohms.

For the measurement of this resistance the method which seems most simple and most practicable is that by a differential galvanometer.

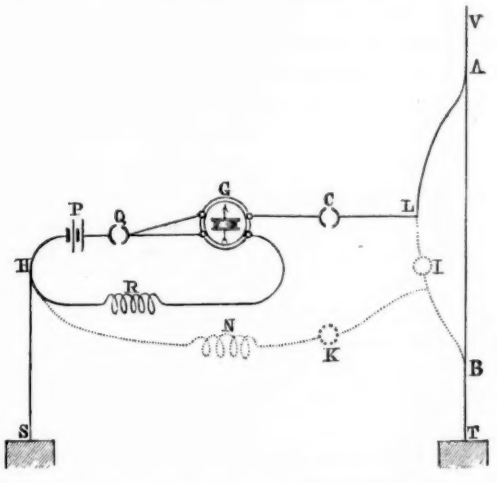
The committee proposes, therefore, to establish in a fixed position in every building provided with a lightning rod, in addition to the principal earth contact, a second contact, completely independent of the first, and situated at 20, 30, or more metres from it, according to the nature of the soil and local conditions, which will be tested as to perfect efficiency, once for all, by a competent person. This second contact will be connected with a wire leading to the experimenting room, and may, moreover, be attached to the principal conductor when not required for making tests.

A wire covered with gutta percha would be carried off from an elevated part, A, of the lightning rod, and would lead to an interrupter, C, insulated in the normal state. This interrupter would allow of connecting at will, by means of a metallic plug, the lightning rod, A, B, with one of the circuits of a differential galvanometer, G. The other extremity of the same circuit would lead to a second interrupter, Q, in connection with a small battery, P, and with the second earth wire, S.

The second circuit of the differential galvanometer would be connected, on one hand, with the interrupter, Q, and on the other, at the point, H, with the auxiliary earth wire, H, S, a resistance, R, equal to that which should not be exceeded by the earth connection between H and T, or about 50 ohms, would be placed in this circuit.

To make the test, we would commence by closing the local circuit, by putting in the plug of the interrupter, Q, which would enable us to ascertain, by the deflection of the needle, whether the battery, P, is in good condition ; then we should put in the plug of the second interrupter, C. The galvanometer needle should return to a state of repose, or even pass to the other side of the zero, if the resistance of the earth is lower than the resistance, R, or 50 ohms, that is to say, if the lightning conductor is in working order. If the deflection should not change in direction it should be ascertained whether the conductivity of the portion of the rod, A, B, is interrupted, or whether the connections with the earth are defective, which would be the case, if, for instance, one of them being formed of a plate, originally immersed in water, had become dry.

This examination should be entrusted to an experienced man, who should be warned by the attendant of the bad state of the connections ; but the experiment could easily be carried further. It would be sufficient to have a second wire, L, B, establishing communication between the commutator, C, and the foot of the lightning rod, in which would be placed an interrupter, I, and to connect this wire with the point, H, by a conductor also provided with an interrupter, K.



In the normal condition the circuit would be closed by the plug of the interrupter, I, which would furnish a second connection, A, I, T, between the summit of the rod and the earth ; to make the first trial, as was indicated above, it would suffice to remove the plug of the interrupter, I, and proceed as before. In order to ensure the continuity of the lightning conductor, metallic plugs should be inserted in the three interrupters, K, C, and Q ; the two circuits of the differential galvanometer being closed, the needle should remain at rest or deviate under the action of the current passing through the rod, if the resistance of the circuit, H, N, K, B, A, L, C, is below that of the rheostat, R. A resistance slightly below, R, placed at, N, would render this test still more exact, and would enable us to make sure that the rod of the lightning conductor and the auxiliary wires offer only an insignificant resistance, and are consequently in good condition. If it were found that the current which ought to pass through the lightning conductor does not do so, the fault could be discovered by arranging a conducting wire in communication, on the one hand, with the interrupter, K, the other extremity being connected with various points of the lightning conductor between B and A.

Lastly, if the principal conductor should be found by experiment to be in good condition, the secondary wire, H, S, should be tested as well, and also the com-

munication with the earth. These tests present no difficulty, and require no complicated instrument, in order to obtain accuracy. The galvanometer may have the ordinary form of the galvanometers at telegraph stations; and as to the battery, it may consist simply of one or two Leclanché elements.

We have indicated 50 ohms as the limit of resistance between the two independent earths; perhaps it would be advisable, in each particular case, to examine whether this limit is sufficient, or if it would not be better to fix a somewhat different value. This value should depend on the more or less advantageous installation of the earth wires.

In order to avoid all danger, it is better that the commutators, C and K, which should be in readiness in the experimenting room, should have, on ordinary occasions, no communication with the lightning conductor, which might be effected by detaching the wires connecting them with the conductor, A, I, B, if the latter be external, or by cutting off, at A and B, the communication of the wire, A, I, B, with the lightning conductor. When there is telegraphic communication with a station situated at a certain distance, the establishment of a second earth wire, H, S, is useless. It is sufficient to connect the point, H, with the telegraph wire itself, placed directly in communication with the earth at its other extremity at the time of the experiment; but then the resistance, R, must be increased by a quantity equal to the resistance of this conductor.

THE ELECTRICAL TRANSMISSION AND DISTRIBUTION OF ENERGY.*

By MARCEL DEPREZ.

(*Continued from page* 174.)

VI.—*Thermic Actions.—Joule's Law.*

A production of heat is the inevitable consequence of the passage of an electric current. Mr. Joule has demonstrated experimentally that the quantity of heat produced in a circuit may be expressed by:

$$Q = I^2 R$$

Q being the heat produced, I the intensity of the current, and R the resistance of the circuit.

This remarkable law might have been foreseen; it is a consequence of the law of Faraday (section I., *a*), and of the law of the conservation of energy as will be seen.

Let us remark first that in a circuit where the current is entirely employed in producing heat, the heat produced is proportional to the total quantity of zinc dissolved in the battery, this heat being merely the reproduction in another form, of the work of chemical energy, as the principle of the conservation of energy demands.

Let us in the first place arrange various circuits and see how the total quantity of zinc dissolved in them will vary.

In one series of circuits we will keep the resistances constant and allow the intensities to vary.

To draw up a table of what passes in each circuit we must remember:

1. The law of Ohm.—The intensity is given by the relation, $= \frac{E}{R}$, E being proportional to the number of the elements, we shall represent this number by E.

2. The law of Faraday.—The chemical action in each element is proportional to the intensity. The unit adopted being indifferent, we will take the value of the intensity to represent the chemical action, or the quantity of zinc dissolved in each element.

3. The total quantity dissolved is equal to the product of the number of the elements into the quantity dissolved in each.

From these considerations there results the following table:—

Number of elements of the battery.	Resistance of circuit.	Intensity of current from formula $\frac{E}{R}$	Zinc dissolved in each element proportionate to intensity.	Total zinc dissolved.
1	1	1	1	1
2	1	2	2	$4 = (2 \times 2)$
3	1	3	3	$9 = (3 \times 3)$
4	1	4	4	$16 = (4 \times 4)$

* *La Lumière Electrique.*

Under these conditions the total quantity of zinc consumed, or the heat produced, is proportional to the square of the intensity of the current.

In a second series of circuits we will vary the resistances in such a manner as to keep the intensity constant.

Under these novel conditions the quantity of zinc is proportional to the resistance. The results are presented in the following table.

On combining these two results, we see that in circuits where the resistance and the intensity vary at the same time, the quantity of zinc dissolved and the heat produced will be proportionate at once to the resistance and to the square of the intensity.

Number of elements of the battery.	Resistance of circuit.	Intensity of current from formula $\frac{E}{R}$	Zinc dissolved in each element proportionate to intensity.	Total zinc dissolved.
1	1	1	1	$1 = (1 \times 1)$
2	2	1	1	$2 = (1 \times 2)$
3	3	1	1	$3 = (1 \times 3)$
4	4	1	1	$4 = (1 \times 4)$

They will then be proportional to the product of these two numbers which brings us back to the law of Joule $Q = R I^2$. If we recall that $I = \frac{E}{R}$ (Ohm's law), we may put this expression in other forms which will be useful to know. We see easily that:

$$(a) \qquad Q = R I^2 = \frac{E^2}{R} = E I.$$

Moreover, this formula, which is applicable to the totality of a circuit, is a particular case of a more general formula; if we consider any portion whatever of a circuit the resistance of which is *r*, and where the difference of the potentials at the beginning and at the end of the circuit is *e* (section II., *b*), the quantity of heat evolved in that portion of the circuit will be equally expressed by the formula—

$$(b) \qquad q = r I^2 = \frac{e^2}{r} = e I.$$

It will be seen that there is no need for any special notation for the intensity I, it being the same in any portion of the circuit as in the total circuit.

Transfer of Thermic Energy.

To transmit thermic energy it is necessary to form an electric circuit, to collect the heat which is evolved in one point of the circuit and to utilise it.

Consequently, in a circuit of the total resistance, R, traversed by a current of the intensity, I, we take a certain portion, and we utilise the heat which is there manifested. Under these conditions the work expended is equal to the total heat, Q, created in the entire circuit; and the work recovered is equal to the heat, *q*, created in the useful portion. We know at once the value of these two quantities; in fact, if we call the electromotive force of the battery E, we have (section VI., *a*)—

$$Q = R I^2 = E I = \frac{E^2}{R}$$

and similarly, if we call the difference of the potentials at the extremities of the circuit utilised *e*, we have (section VI., *b*)—

$$(c) \qquad q = r I^2 = e I = \frac{e^2}{r}$$

The ratio of these two works $\frac{r}{R} = \frac{e}{E}$ is the economic result.

The first expression $\frac{r}{R}$ is very useful, because it enables us to arrange a circuit in such a manner as to obtain any result desired. We see *à priori* that it is desirable to have the useful resistance as large as possible in relation to the total resistance.

If we wish the total work, *q*, as well as the economic result $\frac{r}{R}$ or $\frac{e}{E}$ to remain constant, whatever is the resistance, or, in other words, whatever is the distance of transport, Q must also remain constant; for this purpose $\frac{E^2}{R}$ must be constant; *i.e.*, E must vary proportionally to the square root of R, but as $\frac{e}{E}$ is constant, *e* must vary in the same proportion.

For thermic, as well as for chemical energy, we are thus led to the following laws:—

1. The positive thermic work, representing the total work expended and expressed by $\frac{E}{I}$ and for a given intensity is proportional to E.

2. The negative thermic work is expressed by *e* I, and for a given intensity it is proportional to *e*.

It must be remarked here that a difference of potential is not a quantity distinct from the electromotive force.

In fact, in a closed circuit, P, A, P′, B (fig. 3), if we say merely that there is a difference of potential between A and B, it will be impossible to say *à priori*, in what direction the current will proceed, nor if this difference of potential is due to a positive electromotive force placed at P, or to a negative force placed at P′, or to a combination of the two. The difference, e, between A and B is in itself what is called an electromotive force; there is between them merely the relation of cause and effect. In reality, we do not know the electromotive force, though we must continue to employ this convenient word; there are in the calculation merely differences of potential. In consequence, in the law which we enunciated in section 2, the difference of potential is merely a negative electromotive force if we wish to consider it in this light, and this law, though expressed differently from what we have found in chemical actions is yet the same.

FIG. 3.

3. The economical result is represented by the ratio of the negative difference of potentials and the positive electromotive force.

4. The thermic work expended, the useful thermic work and the economic result remain constant, whatever may be the distance of transmission, provided that the positive electromotive force and the negative difference of potential vary proportionally to the square root of the total resistance of the circuit.

Transfer of Mechanical Energy.

In the foregoing paragraphs we have had to estimate the work produced by a current, and whether we had to do with chemical or thermic energy we found the same expression, $Q = E\,I$. We are about to show that this formula is absolutely general.

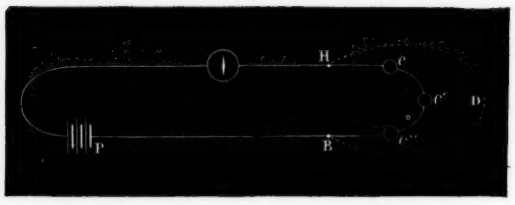


FIG. 4.

Let us consider (fig. 4) a circuit in which is placed a battery, P, of a certain number, n, of elements; a galvanometric apparatus, G, measuring the intensity of the current, and besides, between the points, H and B, a series of apparatus, c, c', c'', suitable for utilising the current, whether in heat, or in chemical action, or in mechanical work. Under these conditions the current takes an intensity, I, indicated by the galvanometer, and there is consumed in each element of the battery a quantity, z, of zinc and, consequently, in the entire battery the quantity, n, z.

Let us now remove the apparatus, c, c', c'', and substitute for them a simple wire, H, D, B, the length of which we vary until the current is brought to the same intensity, I. The electromotive force remains, E; under these conditions the quantity of zinc dissolved per element is always z, according to Faraday's law, and the total quantity is n z. The total quantity of energy produced, which is measured by the quantity of zinc consumed, has not varied; but in the circuit, P, H, D, B, we know that it is represented by E I; this expression gives therefore its value with the circuit, P, A, c, c', c'', B.

Further, in the circuit, P, H, D, B, we can calculate by Ohm's laws the potentials at H and B, as well as their difference, e, and we know that the quantity of energy which can be recovered from the circuit, H, D, B, is represented by e I; if we re-establish the circuit, P, H, c, c', c'', B, nothing is changed in the portion, H, P, B; the potentials at H and B, as well as their difference, e, remain the same; the share of the total work produced in H, P, B, has not altered, therefore the disposable work in H, c, c', c'', B, is still expressed by e I.

If we wish to have these works measured in kilogrammetres according to the units selected above (section III., c), we must express E and e in volts, I in ampères, and divide the product by the number $g = 9{\cdot}81$.

It results from this demonstration that we may in all cases substitute an inert resistance for an active resistance. The value of such resistance is easily determined; if E is the positive electromotive force, e the negative electromotive force, and R the resistance, we have—

$$\frac{E - e}{R} = \frac{E}{R + x}$$

whence

$$x = \frac{e\,R}{E - e}$$

on suppressing e and introducing x, the state of the circuit is not changed.

Transmission of Mechanical Energy

Let us apply these considerations to the case where only two kinds of energy, the thermic and the mechanical, are developed in an electric circuit.

If we call the electromotive force of the generator E, we remark that this force is constant as well as all those which may intervene in one direction or in the other. If the currents were not constant, or, at least, assimilable to constant, currents like those of the Gramme, Siemens, &c., machines, the following reasoning would be applicable only at infinitely small intervals of time, and the solution of the problem would require the use of the integral calculus.

If there are produced in the circuit merely the two energies just mentioned we may, according to the principle of the conservation of energy, write—

$$E\,I = R\,I^2 + T.$$

In this equation E I, as we have just said, represents the total work produced; R I^2, according to Joule's law, expresses the quantity of heat produced, and T the motive work which it is sought to utilise. The intensity, I, is a variable, depending on the value of T; we can see at once that if $T = 0$, *i.e.*, if the current produces merely heat, we find $E\,I = R\,I^2$, or, more simply, $E = R\,I$, the known expression of Ohm's law.

The intensity, I, may be dermined as a function of the other quantities; it is sufficient to resolve the following equation of the second degree which results from the foregoing expression:

$$R\,I^2 - E\,I + T = 0.$$

whence

$$I = \frac{E \pm \sqrt{E^2 - 4\,R\,T}}{2\,R.}$$

Let us examine the various values of T; the expression has the twofold sign ±; let us take first the + sign.

If we make $T = 0$ we find $I_0 = \frac{2\,E}{2\,R} = \frac{E}{R}$, that is the energy developed in an ordinary circuit, without any apparatus for producing mechanical work, according to Ohm's law, and it is the maximum intensity which can be obtained in the given circuit.

If we cause T to increase successively, the value of I will go on decreasing; but we see that T cannot exceed a certain limit, as the quantity under the radical sign cannot become negative. The maximum of T will therefore be obtained for $E^2 - 4\,R\,T = 0$, whence $T = \frac{E^2}{4\,R}$. For this maximum value the value of I will be $I_1 = \frac{E}{2\,R} = \frac{I_0}{2}$. The intensity corresponding to the zero of work is therefore reduced to the half when this work reaches a maximum.

Between these two values the intensity, I, may be considered as the maximum intensity, I_0, diminished by a certain quantity; we write then

$$I = I_0 - i$$

I_0 is, as we know $= \frac{E}{R}$; we can present the variable quantity, i, under the form $\frac{x}{R}$, and we have then:

$$I = \frac{E}{R} - \frac{x}{R} = \frac{E - x}{R}$$

We see that the quantity, x, is presented as a diminution of the electromotive force of the battery, and acts as a negative electromotive force. Accepting this interpretation, and designating it by e, as we have already done, we find:

$$I = \frac{E - e}{R}$$

a formula at which we have already arrived when studying the transfer of chemical and of thermic energy.

The value of e is easy to find; we put:

$$\frac{E - e}{R} = \frac{E \pm \sqrt{E^2 - 4\,R\,T}}{2}$$

whence $e = \frac{E \pm \sqrt{E^2 - 4\,R\,T}}{2\,R}$

This value may be discussed like that of I, and would lead to the same results.

We see that principles already known lead us of themselves, and without experimental study, to conclude that the presence of an electric motor in a circuit is equivalent to the presence of a negative electromotive force.

Experiment had long previously led to a recognition of this fact.

We might have set out from this known point and admitted, as ascertained, the presence of a negative electromotive force produced by the machines employed as motors. It seemed more useful, however, to show that this fact does not depend on the particular apparatus employed, but is connected with the very

nature of things, and that the transfer of mechanical energy is only a particular case of the transfer of energy in general and obeys the same laws.

Let us resume the general formula:—$E\,I = R\,I^2 + T$; whence $T = E\,I - R\,I^2$. $E\,I$ being, as we know, the total work performed the relation $\frac{T}{E\,I}$ will be the economic return K.

The formula, therefore, gives us:

$$K = \frac{T}{E\,I} = \frac{E\,I - R\,I^2}{E\,I} = 1 - \frac{R\,I}{E}$$

which may be written:

$$K = 1 - \frac{1}{\left(\frac{E}{R}\right)};$$

but $\frac{E}{R}$ is merely I_0, therefore $K = 1 - \frac{I}{I_0}$.

On the other hand we know that $I = \frac{E - e}{R}$; we have therefore

$$K = 1 - \frac{\frac{E - e}{R}}{\frac{E}{R}} = \frac{e}{E}$$

We are thus brought back for the economic return as we have been for the intensity to the formula, which we found in the case of the transmissions previously studied, and we recognise that, whatever may be the nature of the energy transmitted, the economic return has for its expression $\frac{e}{E}$, the relation of the negative electromotive force, e, developed in the accomplishment of useful work, to the electromotive force, E, necessary to produce the total work expended.

We can already calculate not merely the economic return, *i.e.*, the relation of the work produced, but its absolute value.

We have, in effect:

$$\text{Total work } T = E\,I = \frac{E\,(E - e)}{R}$$

$$\text{Motive work } T_m = K\,E\,I = e\,I = \frac{e\,(E - e)}{R}$$

$$\text{Quantity of sensible heat (thermic work) } C = R\,I^2 = \frac{(E - e)^2}{R}$$

We must not forget that these various forms of work are those developed in the unit of time, and that if they are to be estimated in kilogrammetres their expression must be divided by the number $g = 9{\cdot}81$.

These various values may be expressed as a function of the economic return $K = \frac{e}{E}$; we find then:

$$T = (1 - K)\frac{E^2}{R}$$

$$T_m = K\,(1 - K)\,\frac{E^2}{R}$$

$$C = (1 - K)^2\,\frac{E^2}{R}$$

If we desire the return, K, to remain constant, and that at the same time the work recovered as well as the work expended should remain constant, whatever may be the resistance, R, and consequently the distance through which the transmission is effected, it is sufficient if the quantity $\frac{E^2}{R}$ remains constant, *i.e.*, that E varies as the square root of R; it is scarcely necessary to point out that $\frac{e}{E} = K$, being constant, e ought to vary in the same manner, which brings us again to the rule already recognised for the transmission of chemical and thermic energies.

Some persons, at first sight, cannot refrain from regarding as singular the fact of the return being independent of distance. It seems to them that the production of heat in transit should increase with the distance, and should, consequently, form a source of increasing loss. This illusion springs from their considering the loss per metre as constant, forgetting that it depends on the intensity of the current, which itself is a function of the distance. The foregoing formulæ show clearly how the events take place and that if the work remains constant the total loss in heat is also constant, the loss per unit of length decreasing with the distance.

Conclusion.

It is, then, not necesary to go further and to await the study of special appliances in order to know the laws of the transmission of mechanical energy; they are demonstrated *à priori* and are formulated thus:

1. The positive mechanical work representing the entire work expended is expressed by $E\,I$; for any given intensity it is therefore proportionate to E.

2. The negative mechanical work is expressed by $e\,I$, and for any given intensity it is therefore proportionate to e.

3. The economic return is represented by the relation of the negative electromotive force to the positive electromotive force.

4. The useful mechanical work and the economic return remain constant, whatever may be the distance of transmission, provided that the positive and negative electromotive forces vary proportionally to the square root of the resistance of the circuit.

It will be perceived that these laws are the same for the transmission of energy, whatever may be its form.

Not to overlook any point, it will be useful to remark that, in discussing the values of I, drawn from the formula

$$I = \frac{E + \sqrt{E^2 - 4\,R\,T}}{2\,R}$$

we have taken into consideration only values of the + sign. Although this method of investigation, as it is easy to see, does not interfere with the generality of the conclusions, it is interesting to study the values given by the sign −.

If we make $T = 0$, we have then $I = 0$. If we examine the value of e, we find $e = E$. This is a case which has already occurred to us in the study of chemical energy. The return is equal to unity; the two electromotive forces, positive and negative, are equal, and being opposite, they nullify each other, and there is produced in the circuit neither work nor electric current.

If we increase T up to the value $\frac{E^2}{4\,R}$, which, as we know, is the maximum, we find a series of values for I, increasing successively up to $I = \frac{E}{2\,R} = \frac{I_0}{2}$.

We see, therefore, that for each value of T there are two values; the one given by the + and the other by the − sign; *i.e.*, a given useful work may always be obtained with two different intensities, corresponding to different electromotive forces.

Magneto and Dynamo-Electric Machines.

It is necessary to limit, in the outset, the meaning of some words which we shall have to employ.

It is needless to recapitulate what is a magnet and what are the agencies which it exerts; the facts and the corresponding terms are known to all.

We call a "magnetic field" every space submitted to magnetic action, *i.e.*, such that the pole of a magnet which is present in this space undergoes a magnetic action, whatever its origin.

The intensity of a magnetic field at any one point may be measured by the energy with which a small magnetic needle, placed at this point, is deflected.

The direction taken by such a needle, shows the direction of the resultant of the magnetic actions at this point, and the totality of these directions constitute the lines of force.

Induction and its Magneto-Electric Laws.

If in a magnetic field, such as that just described, we move a conducting wire, it will be traversed by an electric current during all the time of the movement. The direction of the current is determined by the nature of the magnetic field and the direction of the movement of the wire.

1. The electromotive force in each element of the wire is proportional to the length of such element

2. It is proportional to the speed of movement, taken perpendicularly to the lines of force of the magnetic field.

3. It is proportional, lastly, to the intensity of the field.

Reciprocally:

4. If we direct a current into a wire placed in a magnetic field, the wire will take a movement opposite in direction to that which would have to be given it in order to obtain the same current by the action of the field.

We have here the phenomenon of induction, and such are, in a few words, its principal laws.

The machines which generate electricity utilise this phenomenon; they are essentially apparatus fitted for causing a conductor, or a series of conductors, to pass rapidly, and in as continuous a manner as possible, into one or more magnetic fields and for collecting the currents thus produced.

The magnetic fields of which these machines make use may be due, either to a permanent magnet—when the machine is called magneto-electric—or to an electro-magnet—when we have a dynamo-electric machine. In the latter case the current which produces the magnetisation of the electro-magnet may be either taken from an external source, or—which is the more common case—it may be generated by the current produced by the machine; the intensity of the magnetic field depends then on the action of the machine itself.

We shall reason always as if we were making use of a machine of the Gramme or Siemens system; these apparatus supply currents of a regularity so great that they may be regarded as constant, which is necessary to simplify their study.

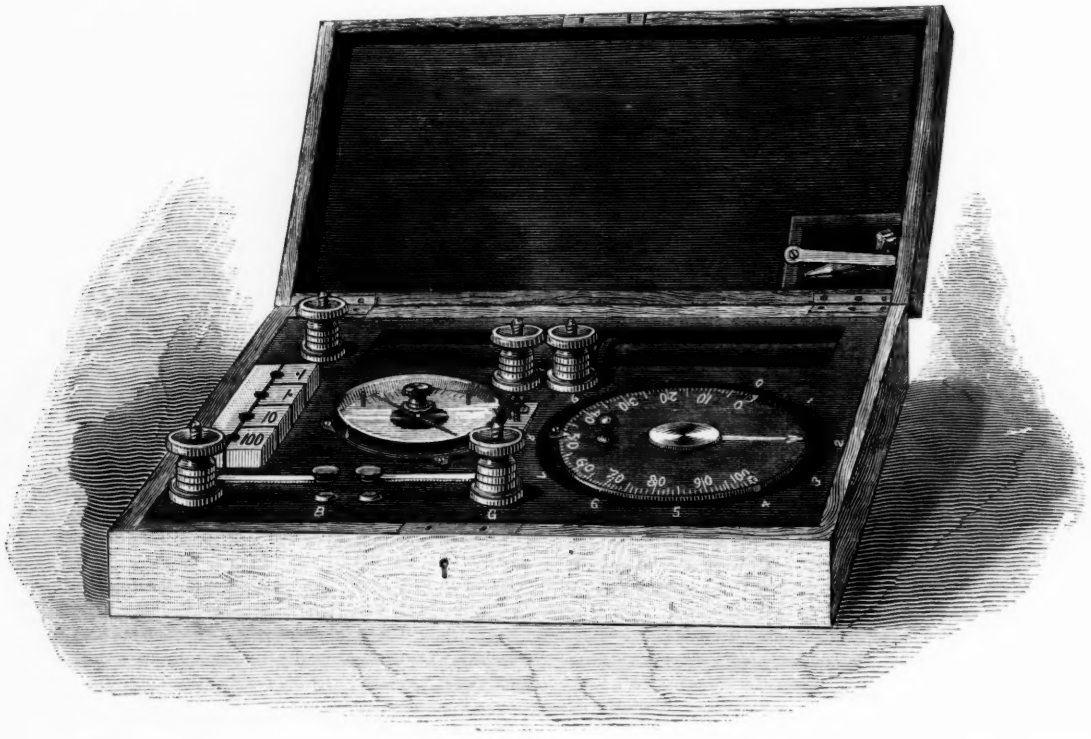
They comprise a system of magnets or electro-magnets, producing a magnetic field, a system which is often called the inductor; in this inducing field there rotates a moveable piece in the form of a ring or bobbin, which supports the conductor in which the current is developed. It forms merely a single conductor, folded back upon itself so that its various parts pass successively and continuously into the magnetic field.

Without need for a precise description, necessarily complicated, we may enunciate the laws which govern the production of the current, and that of mechanical force by the employment of these machines.

(To be continued.)

BLACKBURN'S PORTABLE TESTING APPARATUS.

ELECTRIC light engineers often have occasion to ascertain the resistances of the machines and circuits with which they have to deal, under conditions which make it inconvenient to have at hand the comparatively cumberous apparatus which is usually provided for the purpose. The instrument of which we this week give an illustration has been designed with a view to portability, and to enable it to be used without much time being lost in setting it up. It is made by Messrs. Latimer Clark, Muirhead & Co., and although the last and improved pattern is somewhat larger than that originally introduced, it is still of so small a size that electricians can easily carry it with them. The range and sensitiveness of the instrument are amply sufficient, and it is further capable of forming a useful adjunct to more delicate apparatus in the laboratory, seeing that it is always set up ready for instant use, and that measurements can be made with great rapidity. To combine, in such small compass, so many different parts in a practical form, and to ensure correct reading with the minimum of skill on the part of the operator, necessarily required some little evolution, yet the result has been obtained by taking advantage of known methods without embodying any new principle.



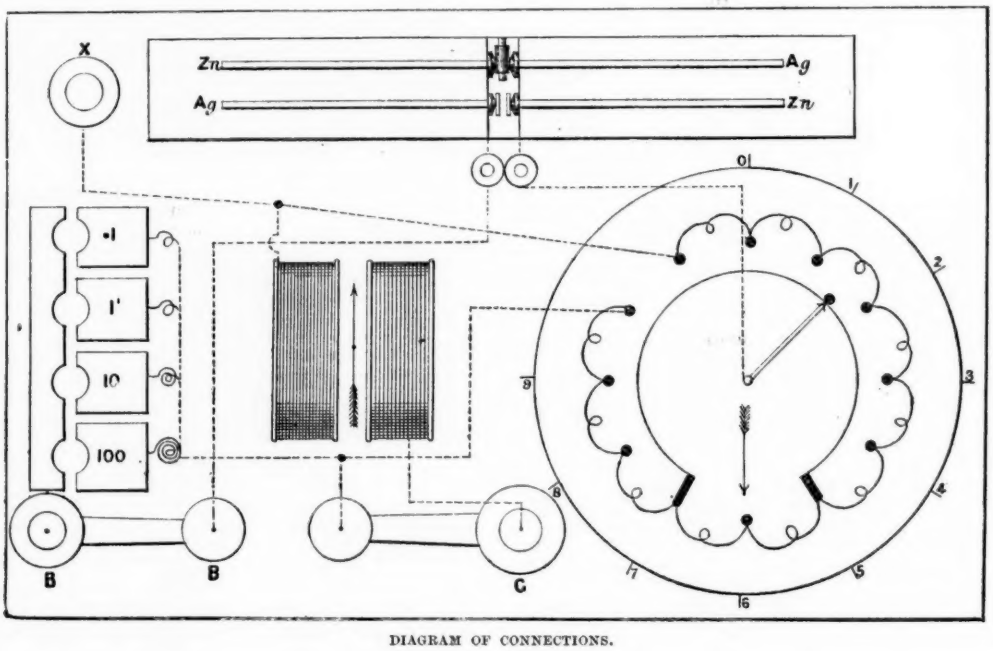


DIAGRAM OF CONNECTIONS.

Chloride of silver elements, wrapped in blotting-paper moistened with a solution of zinc chloride, supply the current. The galvanometer needle is astatic, suspended from a torsion head by a silk fibre, and can be set to zero without it being necessary to adjust the position of the instrument relatively to the magnetic meridian.

A single plug, which, when not in use, is placed in the cover as shown, serves to vary the comparison coils from 0·1 to 100 ohms. A battery and a galvanometer key prevent the extra current due to induction disturbing the balance.

The arrangement of branch coils whilst, as in the ordinary "metre" bridge, permitting of continuous variation in values being read, provides a length of wire the resistance of which bears a due proportion to the other resistances in circuit. The principle is derived from Messrs. Thomson and Varley's well-known slide resistance box. Eleven coils, with contact pieces, are arranged in series in the base beneath the turn-table, this latter carrying two contacts, which serve to embrace two of these coils; a wire having double the resistance of a single coil is stretched round the edge of the table and joins the two contacts, being for final adjustment capable of sub-division at any point by the index-arm which carries the battery current. When used for taking resistances, the connections are made to the two terminals marked X and B. The table is then set with the arrow pointing to such a number as on trial gives the smallest deflection of the needle, a final adjustment being obtained by moving the index arm. The number pointed to by the arrow is then read off as hundreds, that indicated on the table itself as tens and units. The instrument, as we ourselves have observed, gives fairly correct readings from 0·005 to 2000 ohms, but will give approximate readings of a much higher value.

Two terminals (shown close together in the perspective view and diagram) are also provided for the insertion of extra battery power should it be desired to take insulation tests with a higher E.M.E. It would also be possible to measure the sectional resistance of cells by Mance's method, by taking out the ordinary cells, bridging over the two battery terminals, connecting the cell to be measured at X and B, and adjusting the galvanometer either by the torsion head or by an external magnet.

Lastly, the instrument can be used as a simple detector by joining up to B and C, and using the left hand key.

In making a concluding remark on Mr. Blackburn's very ingenious and highly useful apparatus, we would suggest that the containing case should be made somewhat deeper. We do not feel sure but that, as at present constructed, the coils, from the small and cramped space allotted to them, would not, sooner or later, get out of order.

The contact of the rotating arm of the turn-table should also have careful attention, as a source of error might here be easily introduced.

The apparatus only requires to be known to be much appreciated for its portability, ease of manipulation, and the variety of its uses.

GAS AND CALORIC ENGINES.

THE fourth of the six lectures on "Heat in its Mechanical Applications," was delivered on Thursday evening, the 21st of February, before the Institute of Civil Engineers, by Professor Fleeming Jenkin, LL.D., F.R.SS., L. & E., M. Inst. C.E., the subject being "Gas and Caloric Engines."

The lecturer began by defining what he meant by the efficiency of an engine, and stated that the steam engine converted about 10 per cent. of the total heat generated by the coal into mechanical work, or, in other words, had an absolute efficiency of 10 per cent. It was his duty to compare hot-air and gas engines with the results achieved by steam. The first important hot-air engine was that devised by Sir George Cayley, in 1807, which was fully described in his patent of 1837. A diagram of an engine, made by Buckett, was referred to as closely resembling Cayley's engine. Details were given of the theory of the Cayley-Buckett engine, which showed that the results so far were comparable with those obtained by steam, but that there was no great promise of improvement for the future. Gas-engines were next treated of, being also a form of internal combustion engine. The engine designed by Otto, and improved by Crossley, was described as one typical example, and the other chosen was that made by Thomson and Sterne according to Mr. Dugald Clerk's plan. The following points were named as those of chief interest:—the limitation to the higher and lower limits of temperature; the rate at which combustion proceeded inside the cylinder; whether dissociation was a sure course of the limit to the higher temperature; the loss of heat by the cooling of the walls of the cylinder, and the loss of heat in the residual products rejected. Experiments specially made by Messrs. Crossley were described, showing that a change in speed with a constant charge had caused an alteration in the maximum pressure and maximum temperature; but that this change did not extend between wide limits. A change in the richness of the mixture, produced a much greater change in pressure and temperature. A diagram was shown in which the pressure was almost uniform throughout the stroke, and another showing the modification produced in the indicator-diagram when the charge introduced was not allowed to mix with the residual products. All these diagrams tended to prove that gradual combustion certainly took place in these engines, and that the rate of combustion was under control.

A series of very interesting diagrams, illustrating experiments made by Mr. Clerk, was then explained, the rate of combustion in different mixtures of gas and air, and of hydrogen and air, being exhibited by a continuous curve. These experiments established, beyond a doubt, that the rate of combustion varied in proportion to the richness of the mixture, and that this rate was, in the poorer mixtures, such that a considerable portion of the stroke would be completed before the combustion was complete. In fact, Mr. Clerk's experiments and those of Messrs. Crossley nearly agreed, although these makers might differ in their explanation of the cause. The experiments further showed that whether dissociation acted as a limit to the temperature or not, practically the mean temperature of the contents of the cylinder in gas engines at the beginning of the stroke seldom rose above 1550° centigrade. The experiments of the makers further agreed in this:—that the loss by conduction through the walls of the cylinder was a little over 50 per cent., and that at the moment when the highest pressure was attained not much more than one-half of the total heat was developed, the rest being developed throughout the stroke. The lecturer pointed out that the true condition of the burning gases was one which it was extremely difficult to analyse or follow; that within the cylinder there must be an extremely hot kernel at a temperature greatly above the mean; that at the outside there must be a layer little above 150° centigrade, and between these limits layers at all temperatures; that part of the gases must expand receiving heat, and part give it up. But it was interesting to find that the practical result of these complicated actions did not differ widely from the adiabatic curve, although, in point of fact, one-half of the heat was being given up by conduction. Passing from these theoretical considerations to the practical results, the lecturer found a similar agreement. Both makers produced engines giving 1 indicated H.-P. for 20 cubic feet of gas. This result corresponded to one-third, or one-fourth, of the consumption recorded for the early gas engines made by Lenoir. Moreover, they showed that from 16 to 24 per cent.

of the whole of the heat generated was actually converted into indicated H.-P., notwithstanding the enormous waste of one-half by conduction across the walls. In absolute heat efficiency, therefore, the gas engine was already 100 per cent. better than the steam engine. When, however, what might be termed the relative efficiency, was compared, that was to say :—the relation between the theoretical achievement which was possible, and the actual achievement, the steam engine would be found nearly to have reached the limit of what was possible or probable, whereas the gas engine was very imperfect, and therefore gave hopes of great improvement.

Taking the range of temperatures as the highest and lowest used in a gas engine, the ideal efficiency might be spoken of as 77 per cent., but no real gas engine could reach this figure because the heat was not wholly given at the higher nor wholly rejected at the lower temperature. If the indicator diagram were treated as bounded by two adiabatic curves and two vertical lines, the theoretical efficiency of the gas engine with the temperature described would be about 48 per cent., and one-half of this had been attained, the other half being accounted for by the cooling of the walls. The lecturer then passed on to consider what possible means might be suggested for improvement, and divided these into two classes—those in which it was intended to lower the practical temperature of rejection, and those in which it was intended to diminish the loss by cooling. As regarded the first of these—increasing the pressure of compression produced good results by increasing the expansion ; but the advance to be made in this direction was not expected to be great, as the pressures used were already large.

The lecturer next proceeded to describe the Stirling engine, invented in 1827, pointing out that Robert Stirling was the first inventor of the regenerator—a device which had not been fertile so far as heat engines were concerned, but which, in the hands of the late Sir William Siemens, had greatly modified several of the important industries in the kingdom. He pointed out that it was a natural idea to modify the Stirling engine, which received its heat from outside into an engine which, like the Cayley-Buckett or gas engines, received their heat inside, and explained in detail the difficulties that had been met with in several attempts to carry this idea into practical effect. The late Sir William Siemens had worked at the conception during the greater part of his life, and had he been spared a few years longer, there could be no doubt that complete success would have been attained. Professor Jenkin's experiments in the same direction had been chiefly directed to combating the difficulties introduced by the porosity of refractory materials, which was much greater than was usually supposed, even in the case of very dense fire-brick. These experiments had been given up temporarily, under the conviction that the complications involved in introducing internal combustion, whether by gas or coal, into a Stirling engine were such as to render small engines of this type impractical, but without any loss of faith that, for the larger types, they would ultimately be successful. Small engines of the Stirling type were actually in the market, made either by Bailey, Robinson, or Rider. The results from these engines were as good as could be expected from their small size and the low pressure used. They could be made more efficient by raising the pressure, but the complication introduced would probably outweigh the advantage obtained in the saving of coal. The theoretical results to be obtained by the simple adoption of a regenerator, through which the mixture of gas and air passed on entering the cylinder, and repassed on leaving it, were then described, and seemed to show that this device might be serviceable in sensibly increasing the efficiency of engines, and finally some attempts were described by which it was hoped that the great conduction across the walls of the cylinder might be diminished. For this purpose, however, invention was required. In due time it would be forthcoming. In fact, the most interesting point connected with gas engines was this :—that while in the steam engine, the limit of improvement had almost been reached, with the gas engine, the theoretical efficiency was already double that of the steam engine, and the cost of working comparable, especially when Dowson gas was used, and that in the case of the gas engine it was possible to look forward to double and triple the efficiency which had so far been actually obtained.

TESTS OF ELECTRIC LIGHT SYSTEMS.

THE Commissioners of the eleventh industrial exhibition held in Cincinnati in September and October, 1883, determined to undertake a series of tests of the efficiency of electrical lighting systems. Special premiums were offered for the best system of arc-lighting, the best system of incandescent lighting, the best dynamo machine for arc and incandescent lighting respectively, and for the best lamp in each system.

A jury was appointed by the Commissioners, consisting of T. C. Mendenhall, chairman ; H. T. Eddy, Thomas French, jun., and Walter Laidlaw.

The opening of the exhibition took place on September 5th, and the close on October 6th. The jury was requested to make its report of the awards one week before the close.

In response to the proposal of the commissioners, four systems of electric lighting were entered for competition. The Thomson-Houston Electric Lighting Company submitted a system of arc lighting ; the Edison Electric Lighting Company, a system of incandescent lighting : and the U.S. Electric Lighting Company offered a system of arc lighting, and also one for incandescent lighting. Several things conspired to make the tests less complete in some respects than was desired by those interested. The members of the jury were all engaged in professional work, and were therefore unable to devote their entire time to the tests. The dynamometers used were built after the exhibition opened, and were not completed until after many vexatious delays. One of them, that upon which the most reliance was placed, was of a form recently devised, and the principles of which had never been realised in practice, except in an experimental model constructed by its inventor. Its construction on a large scale necessarily involved a good deal of experimentation. In spite of these delays, the jury was enabled to begin regular work on the evening of September 25th, and to make, during the succeeding ten days, such tests of the most important features of the various systems as to justify them in making the awards, whatever difference might have existed in reference to minor points, which, for lack of time, were not thoroughly investigated.

We read in *Science* that the plan adopted was substantially that upon which nearly all similar trials have been conducted. The energy consumed by the dynamo was measured by means of the dynamometers, and the electrical energy in the circuit was determined by well-known methods. This gave the efficiency of the machine as a generator. The illuminating power of the lamps was compared, and at the same time the electrical energy which they consumed was measured. A combination of the results obtained by these two processes gives the relative illuminating power per unit of energy consumed by the dynamo, which represents the relative commercial efficiencies of the systems. The measurements made, therefore, were of three kinds—dynamometric, electric, and photometric ; and they will be considered in the order mentioned.

Dynamometric Measurements.

Two separate dynamometers were simultaneously employed in measuring the mechanical energy expended in running the armatures of the four dynamos which were tested. They have been called, from the manner of their operation, the "belt" and "cradle" dynamometers respectively.

The belt dynamometer has been frequently employed before: and its manner of operation is explained by Dr. Hopkinson in *Engineering*, vol. 27, p. 403, where he gives a figure of it, and the formulæ used by him in determining the power expended in certain electric light tests.

The computation of the power expended from the observations of the belt dynamometer by the theory as at present known was wholly unsatisfactory, giving results, in all except the first few tests, considerably less than the truth, and in some cases less than the electrical power in the circuit.

The cradle dynamometer, however, gave results of a much more satisfactory character. The principle of this dynamometer is a recent invention of Professor Brackett, of Princeton, N.J., and, owing to its novelty and great accuracy, merits a somewhat minute description. It was built at the machine-shops of Messrs. Lane & Bodley, Cincinnati, under the superintendence of Mr. Laidlaw, from designs made by Mr. Eddy, to whom is due the arrangement of its various parts.

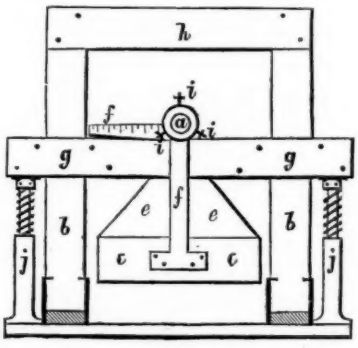


FIG. 1.

It consisted of a substantial platform, *c*, *c*, fig. 1, seven feet long by four and a-half feet wide, hung at each end by iron rods, *e*, *e*, from an axis consisting of a short piece of two and a-half inch shafting, *a*, which rested upon a supporting girder, *g*, *g*. Fig 1 represents the framework, &c., at one end of the platform, to facilitate raising and lowering the girder, *g*, *g*, which carried the platform, *c*, *c*, by means of the jackscrews, *j*, *j*, upon which *g*, *g* rests. The uprights, *b*, *b*, are guides passing through the openings, *b*, *b*, shown in fig. 2, which is intended to represent the ground plan of *g*, *g*, and adjacent parts of the cradle. Each girder, *g*, *g*, was composed of two planks, held at a distance of three inches apart by blocks, *d*, *d*, and bolted firmly together. The rods, *e*, *e*, passed between the planks, *g*, *g*, and were forged to an eye which fitted the axis, *a*. The axis, *a*, rested upon pieces of smooth boiler-plate in the upper surface of *g*, *g*.

The uprights, *b*, *b*, form part of a rigid framework, well bolted together, one side of which is seen in outline on a smaller scale in fig. 3.

A scale beam, *f*, *f*, made in the form of an inverted L and graduated to fractions of an inch, had the lower extremity of its vertical arm fastened to the platform, *c*, *c*; while at the angle was an eye which was centred upon, *a*, by the screws, *i*, *i*, *i*.

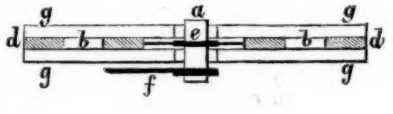


FIG. 2.

It is readily seen that the platform, when it was raised from the ground, as shown in fig. 1, was free to swing through a limited space, either to the right or left, and that any eccentric weight or force so applied as to tend to swing it to the left could be compensated by a weight upon the scale beam, *f*, *f*, which swings with it; so that the platform could be still kept in its horizontal position.

The axis about which the swinging tends to occur is the line of contact between *a*, *a* and *g*, *g*, which line we shall for brevity henceforth call the axis, *a*, *a*.

In setting up the dynamometer, it was so placed that the axis, *a*, *a*, was directly below the driving-pulley, and in the same vertical plane with it. The dynamo to be tested was placed upon the platform, *c*, *c*, while *c*, *c* was resting upon the ground; and it was blocked up on *c*, *c* to such a height, that the axis of the armature was as nearly at the same height as the axis, *a*, *a*, as could be readily done by direct measurement. This adjustment could be effected with all necessary exactness once for all; for, even though the armature were slightly above or below the axis, *a*, *a*, no error would thereby be introduced into the observations.

The axis of the armature was also set, as nearly as it could be conveniently, in line with the axis, *a*, *a*, but the final adjustment, so that the centre of the armature pulley was neither to the right nor left of the axis, *a*, *a*, was made mechanically as follows:—The platform and dynamo were raised from the ground, and the girders, *g*, *g*, carefully levelled by means of the jackscrews. The platform was then brought to a horizontal position by placing compensating weights upon it. The belt was next adjusted, and was tightened by lowering the platform. It was then found, that, in case the axis of the armature was to the right or left of *a*, *a*, the tension of the belt exerted a force to tip the platform, and it no longer stood horizontal. This was corrected—one half, by shifting compensating weights; and the other half, by moving the dynamo to the right or left. The belt was then slackened by raising the platform, and a similar adjustment again made to bring the platform to the horizontal position. This was repeated until the platform stood horizontal, whether the belt was tight or loose; both girders being at the same height, and both accurately levelled, account being taken of the bending.

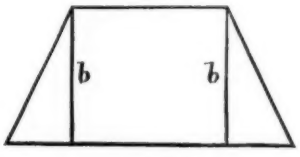


FIG. 3.

A further application of compensating weights was employed to render the balance sensitive. With the Edison dynamo, which is top-heavy (*i.e.*, its centre of gravity is above the axis of the armature), more than a ton was hung on the sides of the platform to bring the centre of gravity of the whole down to the axis, *a*, *a*. With the other dynamos, whose centres of gravity are below the axis of their armatures, compensating weights of smaller amount were placed upon a staging built on the platform above the dynamos, in order to bring the centre of gravity of the whole up nearly to the axis, *a*, *a*,

In making the tests, the power was applied to turn the armatures clockwise in fig. 1. This caused the horizontal scale beam, *f*, to rise; and weights were placed upon it to bring it back to the horizontal position. The moment of the couple, got by multiplying the weight so applied by its distance from the axis, *a*, *a*, as read upon the scale-beam, is evidently equal and opposite to the moment of the couple with which the armature is turned. Thus the moment of the force applied to run the armature was measured in foot-pounds. This moment, multiplied by the number of revolutions per minute and by 2π, is the work expended in driving the armature, in foot-pounds per minute.

It was found convenient to use a weight having a moment somewhat less than sufficient to bring the scale-beam to the horizontal, and employ a Chattillon spring-balance with a dial-face reading to 2 oz. to furnish the remaining part of the couple. This balance was fastened to a vertical cord passing around a small

winch, which enabled the observer to bring the scale-beam to the horizontal with facility.

The principal difficulty to be apprehended in testing with this dynamometer was a possible tendency to oscillation, which might be caused by running the belt. Had this existed, it might have been checked by a dash-pot; but the weight of the platform and dynamo was sufficient to almost entirely obviate any such difficulty, and give very considerable steadiness of position. Indeed, the jarring seemed to increase its sensitiveness, and evidently enabled the platform to come to rest in its position of equilibrium by overcoming any initial friction existing.

The structure was mostly built of three-inch plank, ten or twelve inches wide. The platform was designed to safely carry five tons at its centre.

For permission to make use of the cradle dynamometer, the jury is indebted to the kindness of Professor Brackett.

In addition to the use of the two dynamometers described, indicator-diagrams were taken from the steam-engine furnishing the power for driving the dynamo machines. Throughout the dynamometric tests the machines were driven by a Cummer engine of about a hundred horse-power, which furnished power for other dynamos than that upon the cradle, as well as for two or three pieces of machinery on exhibition in Power Hall. It was thus impossible to make the taking of indicator-diagrams contemporaneous with the regular tests, owing to the large load which the engine carried; and they were generally taken after ten o'clock at night, at which hour the remainder of the load was thrown off. Although these indicator-cards were not used in the final computations, they furnished valuable checks upon the performance of the dynamometers.

The electrical measurements.

For the purpose of making the electrical measurements as free from disturbance as possible, a small room, about twenty feet long and ten feet wide, was fitted up in the basement of the central part of the large Exposition building. In this, three brick piers were built upon solid foundations, and two or three wooden brackets were firmly secured to the walls, so as to furnish firm resting-places for the galvanometers. The main lines of the arc-lighting systems were run through this room, and very heavy copper conductors connected the room with the space in which the dynamos were exhibited; so that the entire current from the incandescent light machines could be introduced when desired.

The electric measurements consisted in the determination of the strength of the current, and the electromotive force between two points in the circuit. For this purpose several galvanometers of different kinds were employed. For the measurement of current strength the principal instrument used was one of Sir William Thomson's current galvanometers, made by White, of Glasgow.

This galvanometer was permanently mounted on one of the stone piers, and its connections were so arranged that it could be quickly thrown in or out of the circuit without interfering with the continuity of the same. The direction of the current through the galvanometer could be instantly reversed; and throughout the observations reversals were regularly made, so as to eliminate error arising from displacement of the zero. The zero-point was adjusted, however, at the beginning of every series of observations, and examined at frequent intervals during the same.

A differential galvanometer was also used in measuring current strength. This instrument was kindly loaned to the jury by Professor Brackett, of Princeton, by whom it was devised and constructed. A description of it will be found in the *American Journal of Science*, vol. xxi. p. 395. It consists essentially of two heavy rings, one within the other, through which the current goes in opposite directions. The needle in the centre has a silk-fibre suspension. The radii of the rings being given, the constant of the instrument can readily calculated. It was especially constructed for the measurement of strong currents, ten ampères giving a deflection of fourteen to fifteen degrees when the value of H is a little more than ·2. When the current was steady, it behaved admirably: but with a fluctuating current it became extremely difficult to get trustworthy readings, owing to the constant vibration of the needle. The graduated circle was so small that the estimation of fractions of a degree was quite uncertain. Even with steady currents, more time was required for reading the Brackett than the Thomson, owing to the length of time needed for the needle to come to rest after a reversal of current. For these reasons its use was not continued throughout the test. It was observed continuously during the tests of the Thomson-Houston dynamo, and during a part of the tests of the Weston dynamo, when, owing to fluctuation in the current, its use was necessarily discontinued. It served a useful purpose, however, as a check upon the indications of the Thomson instrument, the close agreement of the two justifying confidence in the indications of the latter. The most carefully made series of comparisons was that of Sept. 20th. During the afternoon of that day eight simultaneous readings of the two instruments were made; the current, which was remarkably steady, being furnished by the Thomson-Houston dynamo. The means gave 9·92 ampères as indicated by the Thomson, and 9·93 ampères for the Brackett. The regular tests were begun on Sept. 25th, and in the meantime several additional conducting-wires had been brought into the testing-room. The indications of the Brackett galvanometer were, after this, constantly somewhat less than those of the Thomson, which was doubtless due to the alteration of the field by the presence of the currents. The difference was quite constant, and amounted to about two per cent. Thus, on Sept. 25th, the Thomson gave 9·97 ampères, and the Brackett 9·77. On the 26th the Thomson indicated 10·0, and the Brackett 9·80, and on the 27th, with the Western arc dynamo, showed 18·6 ampères, and the Brackett 18·3. That this discrepancy could be accounted for by the effect of the current upon the strength of field was established by vibrating a needle under two conditions—with and without the currents. Herein is shown the advantage of a strong, permanent magnetic field, such as exists in the Thomson instrument. An alteration of the field, which might considerably influence the results from the Brackett, would hardly be perceptible with the Thomson.

During the tests of the arc-light machines the whole current was taken through the galvanometers. With the incandescent systems, however, in which the current was sometimes as high as 170 ampères, this was impossible; as the coils and connections would have been greatly heated. The current might possibly have been safely divided between four or five instruments; but, these not being at hand, it became necessary to make use of a shunt.

For this purpose the heavy main conductor was cut, and the two ends were inserted into large mercury cups, cut out in a block of wood an inch-and-a-half thick. These cups were also connected by about 40 feet of No. 0 copper wire, the ends of both main and shunt wire being well immersed in the mercury and pressed close together. These mercury cups were connected with two others by means of short copper wires, and into the second pair the ends of the galvanometer wires were plunged. As thus arranged about one-fifth of the current was taken through the galvanometer. Even with this division of the current it was found that when using the strong current from the Weston dynamo the wires of the galvanometer were somewhat heated, and in order to avoid this result a short piece of No. 0 wire, not more than 2 or 3 inches in length, was bent so that it could be inserted in the mercury cups, and thus cut the galvanometer out, except during the few moments necessary for taking a reading. During all of the "resting" periods this short wire carried by far the greater portion of the current, and thus tended to prevent the heating of the shunt wire proper as well as of the galvanometer.

The determination of the ratio of the two parts into

which the current was divided, or the value of the "shunt multiplier," was, of course, a matter of great importance. In the preliminary measurement of this ratio the current from the Thomson-Houston machine was of great service on account of its steadiness. To begin with, a number of tests were made to discover if the connection resistances were of such importance that any accidental variation in them would perceptibly alter the shunt ratio. The shunt was repeatedly lifted out of the cups and replaced, and the galvanometer connections were broken and remade. Everything that could be disturbed was disturbed, but upon reconstruction the result was found in all cases to be practically unaltered. On September 28th a series of 20 measurements was made with the shunt alternately in and out, using a current of 10 ampères. The results agreed closely with each other, and gave 4·6 as the value of the shunt multiplier. On the following day the tests of the incandescent machines began, and the shunt was not moved from its position nor disturbed until after the conclusion of the entire work. On October 3rd, after all of the regular tests had been completed, another test of the shunt was made, with a current of 10 ampères, as before. Ten observations were made, all of which agreed in giving a ratio of a little more than 5·0. This result was quite unexpected, and the discrepancy between it and that obtained from the first test was entirely too great to be accounted for by errors of observation. As circumstances prevented further tests in Cincinnati it was determined to remove the shunt and all connections to the physical laboratory of the Ohio State University, where a thorough examination of the cause of the difference could be made. This was done, but before any experimental examination had been undertaken the origin of the difficulty suggested itself. The two short wires connecting the mercury cups had been in one case thrown with the galvanometer doubtless, and in the other with the shunt. It was perfectly certain, however, that throughout the tests they had formed a part of the galvanometer. Upon examination this explanation was at once found to be correct. The shunt and galvanometer were connected up precisely as they had been in Cincinnati, and a series of 25 observations gave, when the small wires were a part of the shunt, a multiplier of 4·60, and when they formed a part of the galvanometer circuit it was 5·01. The measurements were made by comparing the resistance of the two parts of the circuit by means of the fall in potential, as shown by a Thomson's reflecting galvanometer of high resistance. While in use in Cincinnati the shunt was constantly carrying a portion of the current, and its temperature was, therefore, always slightly higher than that of the galvanometer. The difference was small, and it could not be measured accurately; but, on account of its existence, it was thought proper to adjust the shunt multiplier. An excess of heat in the shunt would throw a greater amount of the current through the galvanometer than would go there if the two were at the same temperature; accordingly, the value accepted was 4·9 instead of 5·0, as indicated by the comparison, in which the currents used were much weaker than those transmitted during the tests. It will be observed, the existence of an excess of temperature in the shunt favours somewhat the system in which the stronger current was transmitted.

(To be continued.)

REVIEWS.

The Electric Light in our Homes Popularly Explained and Illustrated. By ROBERT HAMMOND. London: Frederick Warne & Co., Bedford Street, Strand.

Mr. Hammond's work is certainly deserving of praise. It is written in an entertaining manner, and considering the natural favour with which the author must regard those wares in which he is personally interested, it is very free from bias. The descriptions given of the lighting of Mr. Hammond's private residence are very attractive, and appropriately show the advantage of electric over gas lighting. Of the scientific part of the book but little need be said, as the work does not profess to deal elaborately with this portion of the subject. The financial aspect of the question of electric lighting is apparently fairly dealt with, though it must be accepted with caution.

A Short History of the Introduction of Gutta Percha into Europe. By H. W. JEWESBURY. London: 3, Mincing Lane.

This little pamphlet contains interesting information of the history of gutta percha. The gum was first brought to notice in England in 1843, and at the present time the value of the imports amount to over half-a-million sterling. The natural demand for cheapness has, we fear, resulted in adulteration of the material to a very great extent. Anyone who has had to deal with gutta percha cannot but be struck with the difference between the firm, horny nature of the earlier samples of the material, and the brittle and resinous character of the substance which hardly deserves the name of gutta percha, but with which much of the insulated wire of the present day is covered.

NOTES.

Electric Lighting.—A meeting, called by invitation of the Edison & Swan United Electric Light Company, for the purpose of considering the desirability of introducing the electric light into Oban, was held in the Station Hotel on Saturday last. It was well and influentially attended, and Mr. C. T. Grant, of the Edison & Swan United Electric Light Company, explained the present features of that mode of lighting. Mr. Sim said they had five and a-half miles of street in Oban, and supposing they were allowing 40 lamps to the mile, he asked what the cost of that was likely to be. Mr. Grant replied that the dynamo would cost £200, engine and boiler £100, and for the lamps and cable, £300 more. The working expenses of the lamps for 1,000 hours lighting would be £42, fuel £50, and the other expenses might bring it up to £150 annually. Several gentlemen were of opinion that water power was available, and Mr. Anderson thought the company should undertake the lighting of the town for five years at £300, the town to take it over after that period. Mr. Grant replied that his company had now got beyond the experimental stage. If Oban now proceeded in the matter it would be the pioneer town in Great Britain in the subject of electric lighting, and on that account his company would give them every encouragment should they enter into the scheme now. He thought it would be best to form a small company, say with a capital of £2,000 or £5,000. It was casually stated that, compared with gas at 8s. 4d., the cost of the electric light at Oban, with the plentiful supply of water for motive power, might probably be between 3s. and 4s. for the same area lighted.

The American Electric and Illuminating Company recently bought a factory in Montreal, and this, the Canada branch, is under the management of Mr. M. Lee Ross. Seeing the necessity of placing the American arc system before the public of Montreal, he commenced, on the 24th day of January, to build a 200-light station. A portion of the St. Lawrence Paint Works, which was used for coal storage, was rented, properly remodelled, shaftings, pulleys, &c., ordered, a five and a-half mile circuit built, 101 arc lights placed in position, and within seven days from the day of starting all was in full and complete operation. This, to the best of our knowledge, says the New York *Electrical Review*, is the quickest work on record in electric lighting.

The Brush Electric Light Company, of Buffalo, U.S.A., is erecting a new station for 600 lights. It will

be equipped with ten 60-light dynamos, driven by ten independent engines of 65 horse-power each. The contract for the power has been awarded to the Westinghouse Machine Company, of Pittsburgh, Pa., their automatic engines having been adopted, after a competitive test extending over nearly a month.

The Australasian Electric Light Company has secured a very good contract for the lighting of the Princess's Theatre, Melbourne, also sale for arc plant at Brisbane, in Queensland, and Riverstone, in New South Wales, and an order for the lighting of the *Brisbane Courier* office.

In a recent issue of the *Graphic* appeared the following: "It may interest you to know that at a dance I gave last week I had the dancing-room and hall lighted with the electric light. It being an experiment, I was somewhat doubtful as to the result, but it proved a most perfect success. If people only knew how easily and inexpensively such a lovely effect could be produced in a ballroom, I am sure very few good dances would be lighted by gas or candles. The lamps were those of Swan, in small glass globes, with ornamental Venetian glass shades, and the rooms, although lighter and prettier than I have ever had them on previous occasions, were never too hot or stuffy as is often the case, and the light, contrary to expectation, proved most becoming both to the ladies and their dresses. There was no trouble or inconvenience at all. The company's men came the afternoon of the dance, bringing the batteries and everything, and in about two hours all was ready, and the lights burned most brilliantly the whole night without a single hitch. Next morning the men came and took the whole thing away in an hour or two, without a blemish to walls or paint; in fact, the experiment was in every way a success."

The electric light is about to be experimentally tried in Greenock. The Town Council has made the necessary arrangements as to area, machines, &c.

We learn that the mansion of Mr. Inman, at Dawpoole, on the River Dee, near Birkenhead, is being fitted with a large number of Swan incandesence lamps. The main cables for this purpose are made up of nineteen No. 7 copper wires insulated with Callender's compound.

The Great Western Electric Light Company is, we are informed, making use of Callender's wires in an installation for Mr. Gibbs, of Baron Court, Bristol.

The Marquis of Salisbury has been making considerable additions to the electric lighting plant at Hatfield. New rooms in the house are being supplied with the electric light. The main wires, insulated with Callender's compound, are placed underground, and about ten machines (Brush and Siemens) are employed, one being situated about two miles from the house. The weeds in the River Lea have been cut, and the dredging of the lake in the grounds attached to Hatfield House accomplished, by means of electricity.

We understand that the Anglo-American "Brush" Corporation has secured the contract for fitting up an electric light installation on board the *Colossus*.

A new cupola for iron foundry purposes has recently been introduced to the trade by Messrs. Thwaites Bros., of the Vulcan Iron Works, Bradford. This cupola, which has been patented by Mr. Stewart, the general manager of the Vulcan Works, has already attracted a good deal of attention, and seems very likely to come into general use. It may be mentioned that Messrs. Thwaites Bros. are now using, very successfully, the electric light. Mr. Wilson Hartnell, of Leeds, advised the introduction of the Crompton-Burgin system. The installation consists of a small Crompton-Burgin dynamo machine, and six double differential arc lamps (Crompton and Crabbe's patent). It is found by Messrs. Thwaites that the light thus given is perfect for their purpose, and the lamps and the dynamo require very little attention, and are kept in order by one of the workmen in the employ of the firm. After having been at work for several months, it has on all hands been pronounced a most unqualified success.

Mr. W. H. Preece, in his lecture on Wednesday evening at the Society of Arts, pronounced electric lighting a practical success. What had proved a disastrous failure was electric company mongering and electric lighting finance. People would pay a reasonable price for electric light, whatever might be the price of gas. At present it is a luxury, but the progress made was so rapid that the day was not so far distant when it will be demanded as a necessity.

We understand that the Leeds Corporation electric lighting contract is not yet definitely settled. It was thought that Messrs. Paterson and Cooper had obtained it, but we hear that some obstruction has been imported into the matter by a well known firm of electrical engineers.

A trial was made at the beginning of the week of the "Tower" spherical engine at the works of the British Electric Light Company. We recently described and illustrated this engine, which appears likely to meet with considerable success for driving electric light machinery.

The Electric Light in Houses.—In the discussion which followed the reading of Mr. Killingworth Hedges' recent paper before the Royal Institute of British Architects, Mr. Blakesley said that he had experimented with Mr. Hedges' safety fuses, and had found them act with astonishing regularity. He gave a detailed account of the tests to which he had subjected them, and could testify from experience that when properly managed, when the contact is good, and due care is taken that they are of the proper size, they come off with great accuracy. Without such apparatus electric lighting would be extremely dangerous, but when these fuses could be implicitly trusted to melt under the stress of a known current, electric lighting became perfectly safe. Mr. R. E. Crompton also made some sensible remarks with the object of showing how to minimize overheating by means other than cut-outs, whether those of Mr. Hedges or of anybody else. Out of 70,000 or 80,000 lights with the fixing of which his firm had to do, they had never had an overheated wire, and the reason was that they had never condescended, for the sake of false economy, to cut wires down too fine. Of course there would be those who, in the race of trade rivalry, would speculate in paltry savings, and the result would be fires and other troubles, so that electric lighting would get a bad name. Respectable firms would look to architects to help them in this matter, by seeing that the work is properly carried out under sufficient specifications and due inspection, not forgetting to have the wires fairly tested.

American Electric Light Companies' Dividends.—At a meeting of the directors of the American Electric and Illuminating Company, Boston, on the 12th ult., dividends were voted as follows:—The guaranteed semi-annual dividend of 4 per cent. on the preferred stock; an extra semi-annual dividend of 2 per cent. on the preferred stock; and a semi-annual dividend of 2 per cent. on the common stock. A 10 per cent. dividend payable alike to the preferred and common stockholders from the stock of subordinate companies now held in the treasury of this company, was discussed, but as two members of the board were absent, further consideration was postponed until the next meeting.

Electric Lighting v. Gas.—At the half-yearly meeting of the Liverpool Gaslight Company last month, Mr. Edward Lawrence, who presided, said he had been rather amused by a paragraph that appeared in a local paper with reference to the company, and he felt some difficulty in finding the grounds on which the writer based his opinions. He said: "The electric light in the central thoroughfares has been pronounced a decided success, and new discoveries are constantly being made as to the possibility of producing the light at a

reduced cost. Under these circumstances, the prospects of the gas shareholders are as dim as the gas lamps are in comparison with the electric illuminators in Church Street and the other thoroughfares. The days of gas extravagance and high dividends are evidently numbered." He (the chairman) had made a good many inquiries with regard to these illuminators, and he did not find that the general opinion was one of such unqualified satisfaction as the writer of the paragraph adopted. Indeed, he was told that the electric lamps were not only very unsteady, but that occasionally they went out altogether. If such were the case, it only showed that the electric light had not yet attained such a degree of perfection as to make it a very dangerous competitor with gas. He had never spoken in any unfair spirit of electricity, but he had held that they must look forward to it as a competitor, and that it was impossible for anyone to predict what electric science in the present day would accomplish; but all he need say at present was that there was nothing accomplished that need make gas shareholders uneasy with regard to their property, for the electric light could not yet compete with gas.

Electric Lighting Provisional Orders.—An extension of time has been granted by the Board of Trade for the appropriation and deposit of capital in the case of the following orders:—St. James' and St. Martin's, till Oct. 15, 1884; Hanover Square district (London), do.; Strand district (London), do.; Victoria district (London), do.; Hampstead, do.; Canterbury, June 14, 1884; Croydon, do.; Gravesend, do.; Maidstone, do.; Margate, do.; Rochester, do.; Ipswich, do,; Lowestoft, do.; Luton, do.; Sudbury, do.; Aston, do.; Balsall Heath, do.; Dudley, do.; Saltley, do.; Wednesbury and Darlaston, do.; West Bromwich, do.; Birmingham, do.; Redditch, do.; Walsall, do. We believe that in no case has any deposit been paid.

Jablochkoff Electric Light and Power Company, Limited.—Mr. Justice Pearson has ordered that the voluntary winding up of this company be continued, but subject to the supervision of the Court.

Lighthouse Illuminants.—In reply to Colonel King-Harman in the House of Commons on the 14th ult., Mr. Chamberlain said the committee appointed to report upon lighthouse illuminants had been dissolved; but further experiments were to be made at the South Foreland, under the supervision of the Trinity House, in which the Commissioners of Northern Lighthouses had promised to take part. The Trinity House had also communicated with the Commissioners of Irish Lights, and it was hoped that they would join in the observation of those experiments. It was further in contemplation to issue invitations to competent observers from the United States and France, as well as to masters of vessels and pilots passing through the Straits of Dover. The experimental lights will probably be exhibited about the end of this month.

The Post Office Telegraph Ship, "Monarch."—The *Monarch* left Charlton, on Monday last, for the Silvertown Telegraph Works, to ship part of the various cables which are now being manufactured there for H.M. Post Office. In order to try her deck machinery, which has been put up by Messrs. Johnson & Phillips, the cable was hauled on board by means of the picking up gear, and the way in which the work was done gave every satisfaction. After the necessary cable had been shipped, the *Monarch* left, on the 5th inst., for Greenhithe, and after adjusting compasses will make for Jersey, to lay a new 3-conductor cable from thence to Guernsey. We understand that on the completion of this work she will sail for the north, to repair the Islay and Shetland cables, and then to return again to the Silvertown Works to ship the new cable which will be laid between Dartmouth and Guernsey. We wish the *Monarch* every success on this, her maiden trip.

Telegraph Communication with Holland.—We may expect that the telegraph service with Holland, which has been very defective of late, owing to the interruptions of both the Landvoort cables, as well as through the breaking, later on, of the Belgian cables, will soon be put to rights again. The repairing vessel of the Submarine Telegraph Company, *Lady Carmichael*, returned on the 4th inst. from repairing the Jersey cable, and after having taken on board the necessary four-conductor cable, made at the Silvertown Works, left the river again on the 6th inst. After calling at Lowestoft, she will start for the Dutch coast to repair the Landvoort cables.

Irish Telegraph Service.—Mr. Fawcett, in reply to Mr. Harrington, who, in the House of Commons on Friday, the 29th ult., asked why the employment of females in the Postal Telegraph service in Ireland is not more general, said that the department is anxious to employ women, but there were often difficulties in consequence of the post-office buildings not allowing separate accommodation. With regard to telegraph schools, new entries were taken into the instrument room, and the system was found to work remarkably well.

Cable Interruption.—The agent of the Eastern Telegraph Company, Limited, sends the following:—With reference to the interruption on the St. Vincent (Pernambuco) section of the Eastern Telegraph Company's cable, from tests received from St. Vincent, the break is placed from five to ten miles from the shore, in about 300 fathoms. The steamship *Scotia* leaves the Thames on Monday next, and I have every reason to hope that the repair will be shortly completed and telegraphic communication with South America restored.

The Bennett-Mackay Cable.—The money article in Wednesday's *Daily News* contained the following announcement:—"Anglo-American telegraph stocks have further recovered to day on confirmation, by an impartial but good personal authority, of the rumours that the contract for making two new cables for the Bennett-Mackay Company shall be limited to the making of one, so that the competition with the existing cable companies will derive its severity chiefly from the independence of the new company, and not from its power of absorbing much of the business which may be current when the cable shall be laid.

Submarine Telegraph Cables.—Mr. Pender asked the Under Secretary of State for Foreign Affairs, on Friday, the 29th ult., whether the International Conference of Delegates from thirty States, which sat in Paris in 1882 and 1883, on the subject of the protection of submarine telegraph cables, had come to any agreement; and, if so, whether it was likely that any convention would be concluded, and if he would lay the papers connected with the same upon the table of the House. Lord E. Fitzmaurice: The draft of convention drawn up by the delegates at the last conference has since been under the consideration of the Governments represented. An agreement has now been arrived at, and as soon as the requisite authority has been received by the plenipotentiaries of the several Powers in Paris the convention will be signed. The signature is expected to take place very shortly, and as soon as possible afterwards the convention will be laid before Parliament.

Proposed Cable from Spain to Morocco.—The *Times* correspondent at Madrid states that a Spanish company is negotiating for a concession to lay a telegraph cable between Tangier and Tarifa.

Lecture.—Last week, Mr. William Lant Carpenter, B.A., B.Sc., F.C.S., delivered before a large audience in the Literary Institute, Edinburgh, a lecture on "The dynamo machine, and its uses in electric lighting, and in the transmission of power."

Overhead v. Underground Wires.—The Edinburgh Stock Exchange Association have brought under the

notice of the Postmaster-General the effect of recent storms on telegraphic communication with the south, and urged the desirability of the service being improved by an underground system of wires—not necessarily superseding the present system, but acting as an auxiliary, and in contingencies as a substitute for the air system.

Telephonic Experiments.—An interesting balloon ascent was made, says the *Daily News*, at Naples last week. The aeronaut, Mr. Blondeau, was accompanied by a townsman and Mr. Molteni, the sub-director of the Telephone Company of Naples. The latter gentleman made experiments on telephonic correspondence with the earth; and though one of his wires broke almost immediately, the other acted well enough, and the voice of his assistant reached him loudly and clearly. The remaining wire, however, shortly became entangled with the telegraph wires over the city, and Mr. Molteni was obliged to abandon it, but before doing so he had noticed that electric currents had been established, proceeding from the earth to the balloon, and accompanied by crackling sounds. The particulars given by our daily contemporary appear to be somewhat vague and unsatisfactory, but probably more information will shortly be forthcoming.

The Heating of Dynamos.—At the last meeting of the Society of Telegraph Engineers and Electricians, it was remarked that after a dynamo had been running for some time and was then stopped, the heat in the machine gradually increased for some length of time. This has been known since the early days of such machines, and the explanation appears to us a very simple one. When the machine is running a great draught of air is created, which tends to keep the temperature down to a certain degree; but so soon as it is stopped this cooling effect no longer exists, and the heat in the machine gradually, and up to a certain limit, makes itself more and more apparent.

Copper-Steel Overhead Wires.—It appears that the Postal Telegraph Company of America has now in operation a through line between New York and Chicago, consisting of two copper conductors with steel cores, each 500 pounds to the mile, and one steel cored copper wire of 200 pounds; and between New York and Washington the company has run two 500-pound compound copper wires with steel core. The company is said to be pushing on vigorously with the intention of connecting, by its heavy copper-covered wires, all the principal cities in the United States. A line from New York to Boston and through New England is now under contract, and a second line between New York and Chicago, by way of Harrisburg and Indianapolis, with a branch to Cincinnati, is to be built during the coming summer. The poles required to carry the heavy postal wires are put up 40 to the mile.

Personal. — American exchanges state that Mr. Theodore Torrey, formerly of the old Western Union Telephone department, and more recently of the London and Globe Telephone Maintenance Company, will now represent the Utica Fire Alarm Telegraph Manufacturing Company, of Utica, N. Y.

Patent Self-Binding Telegraph Insulator Company, Limited.—This company is making steady progress with Lewis's Self-Binding Insulator, and is not only supplying several leading railway and telephone companies with it, but several of the London telegraph engineering firms, for export purposes. The company has also sent out a large quantity to America, Canada, and other parts. So far the company has not received a single complaint respecting the insulator from anyone, and there is every prospect of its becoming very generally adopted. Most of the insulators are fitted with Lewis's patent screw bolt, which, by a simple modification of the well known screw bolt, allows for expansion and contraction, without the necessity of using any yielding adjunct, such as rubber washers, &c. Upwards of 10,000 of these bolts have been "up" during the last six months, and not a single instance of splitting or bursting of the insulators has been reported. The lathes which make the insulator are now so fully employed, that, while additional ones are being constructed the men are working overtime in order to keep up with orders. Considerable improvements have been made in detail, especially in the clip, which is now made, accurately, of Bessemer steel, and altogether the insulator has a thoroughly "finished" appearance.

Society of Telegraph Engineers and Electricians.—The next meeting of this society will take place on the 13th inst., at the Institution of Civil Engineers, when Mr. W. H. Massey will read a paper entitled "Notes on a Train-Lighting Experiment."

Central News, Limited v. Eastern Telegraph Company and Others.—On behalf of the defendants, Mr. Charles Russell, Q.C., and Mr. Moulton appealed to the Lord Chief Justice and Mr. Justice Watkin Williams against an order made by Mr. Justice Mathew at chambers relative to the discovery of documents in this action, which was brought for the divulgence of the news transmitted from the correspondent of the plaintiff company at Alexandria, to London, announcing the fall of Tel-el-Kebir, whereby it was alleged that the Central News lost the advantage of being first in the market. The defence was that the news was disseminated by the Electric News Company before the plaintiff charged the defendants with having surreptitiously obtained this news, and the application to the learned judge at chambers was made on the ground that it would be a convenience to the defendants, and a saving of expense if the Electric News Company were ordered to produce copies of their printed tape relative to the fall of Tel-el-Kebir. This had been refused, and the Lord Chief Justice now said that the decision of the learned judge at chambers must be affirmed, no case having been made out for the production of the documents in question.

Overhead Wires.—The Railway Commissioners had before them on Friday, the 29th ult., an application for directions as to the mode of procedure in the case of the arbitration between the Postmaster-General and the Wandsworth District Board, held before the stipendiary magistrate, Mr. Paget. Mr. Lane appeared for the Wandsworth District Board, and stated that the Act of 1863 gave an absolute right of veto to prevent the erection of overhead wires; but the Act of 1878 modified that by giving power to the stipendiary magistrate to act as arbitrator, and if the parties were dissatisfied with the award, as in this case the Wandsworth Board were, then the parties could go before the Railway Commissioners. After some discussion it was decided that the parties should come before the Commissioners, not on appeal from the arbitrator, but as a court of first instance trying a case *ab initio*.

It is said that the Goverment has so far yielded to the pressure that has been put upon it by the metropolitan vestries, in the matter of overhead telegraph and telephone wires, that it has arranged that a conference of the Postmaster General with representatives of other Government departments concerned, and of the various private companies interested, should take place for the purpose of discussing the necessity for the introduction into Parliament of a measure giving powers of control over such wires to local authorities through whose districts they pass.

Electrical Communication between Lightships.—Mr. D. Grant, on Thursday evening, the 28th ult., asked the President of the Board of Trade whether his attention had been directed to the necessity that electrical communication should exist between the more important lightships around the coast and the stations on the shore, so as to enable aid to be sent as rapidly as

possible to ships in distress. Mr. Chamberlain said he had authorised an experiment in this direction to be made at Harwich.

British Association for the Advancement of Science.—Meeting in Montreal, August 27, 1884. Notice of Special Discussions in the Section of Mathematical and Physical Science. In accordance with a resolution of the Committee of Section A (Mathematical and Physical Science), Sir W. Thomson, President-elect, passed at the meeting in Southport (1883), the organising committee of the section have selected the undermentioned subjects for special discussions during the meetings in Montreal (1884). The organising committee hereby invite mathematicians and physicists to co-operate with them in sustaining the discussions by contributing original papers or oral communications bearing on the selected subjects. In order that the best arrangements may be made, the names of those who propose to read papers or are willing to take part in the oral discussions should be sent not later than June 1, 1884, to the Secretaries of Section A, British Association, 22, Albemarle Street, London, W. No paper should in reading occupy more than fifteen minutes, and no speech more than ten minutes. Communications on other subjects in mathematical and physical science will, as heretofore, be cordially welcomed, and of these notice should be sent to the secretaries, as above, not later than July 1, 1884. Subjects selected for Special Discussions :—1. On Friday, August 29 : The seat of the electromotive forces in the voltaic cell. 2. On Monday, September 1 : The connection of sun-spots with terrestrial phenomena.

Removal.—Messrs. Woodhouse and Rawson have removed from their former business premises at Charterhouse Buildings to Cadly Hall Works, Hammersmith Road, about 300 yards from Addison Road Station.

Electrically-worked Railway Signals.—The successful working of a set of railway signals and points has recently been witnessed at the works of the Gloucester Waggon Company, Gloucester, the signals being actuated direct by a new electro-magnetic arrangement. This consists of a long-pull electro-magnet, the invention of Mr. Stanley Currie, which has been wedded to a system of interlocking railway signals and points devised by Mr. Illius A. Timmis, C.E., of No. 2, Great George Street, Westminster. The bobbin of the Currie electro-magnet is said to consist of an annular chamber of soft iron in which the coils are placed, the central portion of the chamber being hollowed out to receive the stem of the armature, for which it acts as a guide during its descent. The armature is composed of a pair of soft-iron plates of the same diameter as the bobbin, carried on the stem just referred to, and having a rim of iron on its circumference, the whole forming, as it were, a lid or cover to the bobbin. The inside of this rim is stepped, and the bottom of its outer and thinnest edge is corrugated. The outer portion of the stem of the armature is of iron, and the lower part of gun metal. The result of this arrangement is that instead of the action being practically instantaneous, the impact very violent, and the pull very short, as in the ordinary electro-magnet, the action is very gradual, the impact gentle, and a pull of several inches is obtained, hence its name—the long-pull electro-magnet. The length of the pull, moreover, can be graduated according to requirement, and the principle involved is capable of application whenever a mechanical pull is required. As applied to railway signals, the electro-magnet is carried in a small box attached to the top of each signal-post, where it actuates the signal-arm direct. This arm, in its normal condition is at "danger," and when the electric current is running through the magnet, and it is in work, the arm is pulled down, giving the signal "line clear." It can be held down in that or any intermediate position for any length of time with a small current. If, however, any rod or wire is broken, or if anything goes wrong with the apparatus, the signal-arm instantly flies up to "danger." At this point, and under all circumstances, there comes into operation another device which is due to Mr. Timmis. This is a simple locking bar, so arranged as of itself to automatically and mechanically lock the signal at "danger," and to retain it there until released by the electro-magnet, or, in the case of accident to the gear, by some extraneous means. The signals, together with the points, are worked in the usual way from a signal-box, although the details of the apparatus differ from those in ordinary use. The batteries are also placed in the signal-box, those used at Gloucester being the Faure-Sellon-Volckmar accumulators, although primary batteries can be employed. The signals at Gloucester form a complete set, consisting of a distant signal arranged to be equivalent to a distance of 1,000 yards ; home signals and junction starting signal, controlled by the station in advance, and rail treadles, point and signal levers interlocking one with another. The system has been in work for the past two months, and has been operated under every possible condition, including the recent gales, during which it was worked with the low power we have indicated. It is already under trial on the London, Brighton, and South Coast Railway by Mr. Houghton, the company's telegraph engineer, as well as by the Swansea Dock and Harbour Board in connection with their system of railways.

On the Variations of the Electromotive Force in Accumulators.—By M. E. Reynier.—The experiments in question refer to three forms of secondary batteries ; 1st. The Planté accumulator (reduced lead, peroxide of lead, water acidulated with sulphuric acid) ; 2nd. The copper accumulator (lead coated with copper, peroxide of lead, acidulated solution of sulphate of copper) ; 3rd. The accumulator with amalgamated zinc (lead coated with zinc, peroxide of lead, and acidulated solution of peroxide of zinc). The three specimens experimented upon were not completely *formed*. Measurements of electromotive force have been made during the charge and the discharge, by the method of equal deflection. My experiments confirm and extend the observations—now no longer ancient—of M. Gaston Planté on the variations of electromotive force in the accumulators. The following are the results of my investigation :—

I. In the three systems of accumulators studied, the secondary electromotive force is decidedly higher during the charge than during the discharge. The ratio of the smallest of these values to the greatest may be called the coefficient of decline ; it is a *factor of loss* affecting the yield of the accumulators.

II. The transient super-elevation of the electromotive force increases—

1. With the intensity of the current of charge ;
2. With the electromotive force of the source.

III. In the Planté accumulator, the electromotive force is at least 1·95 volts during the charge, and at most 1·85 volts during the discharge. The coefficient of decline is, therefore, under the most favourable conditions, 0·95.

IV. In the copper accumulator the electromotive force is at least 1·43 volts during the charge, and at most 1·25 volts during the discharge. The coefficient of decline is, therefore, under the most favourable conditions, 0·87. The copper accumulator is the one which loses most.

V. In the zinc accumulator the electromotive force is at least 2·4 volts during the charge, and at most 2·36 volts during the discharge. The coefficient of decline is 0·983 under the most favourable conditions. The amalgamated zinc accumulator is the one which loses least.

VI. In practice the losses experienced by the variations of electromotive force will be always greater than those just indicated.—*Comptes Rendus.*

On the Skrivanow Battery (Pocket Model).—By M. D. Monnier.—The element is formed of a plate of zinc

and of chloride of silver plunging into an alkaline liquid composed of 75 parts of caustic potash to 100 parts of water. The case is formed of a small gutta-percha trough, which can be closed hermetically. The conducting wires and the external contacts are of silver. The entire element weighs only 100 grms. (= 3½ ozs.). The electromotive force of such an element is 1·45 to 1·50 volts. It can yield a current of one ampère for about an hour. At the end of this time the potash solution must be renewed. After two or three renewals of the potash solution, fresh chloride of silver must be taken.—*Comptes Rendus.*

NEW COMPANY REGISTERED.

Electric Apparatus Company, Limited.—Capital £12,000 in £10 shares. Objects: To acquire the business of wholesale and retail dealers in electric apparatus carried on by Mr. Gustav Binswanger, at 4, Trafalgar Buildings, Charing Cross, for £6,000, in fully paid shares and the cost price of the stock-in-trade, &c., less 10 per cent. discount. The company will also have a 12 months' option of purchasing the business carried on by the vendor at 29, Aldermanbury, the consideration being £2,000 in cash and £2,000 in fully paid shares. Signatories (with one share each): *R. Davis, Monument Yard; G. Darling, 2, Aldermanbury Avenue; *G. Binswanger, 4, Trafalgar Buildings; A. P. Friend, *J. Boyd, C. L. Clarke, and H. T. Gaddum, of Manchester. The signatories against whose names an asterisk is marked are the first directors, and the vendor is appointed managing director. Registered 27th ult., by Messrs. Marsland, Hewitt & Everett, 124, Chancery Lane.

OFFICIAL RETURNS OF ELECTRIC COMPANIES.

Electric Lighting, Supply, and Fitting Company, Limited.—The annual return of this company, made up to the 18th ult., was filed on the 3rd inst. The nominal capital is £20,000 in £10 shares. 607 shares have been taken up and the full amount has been called thereon. The calls paid amount to £5,988, being £200 in excess of last year. The unpaid calls amount to £82. Registered office: 28, York Street, Westminster.

Edison Gower-Bell Telephone Company of Europe, Limited.—The annual return of this company, made up to the 22nd ult., was filed on the 28th ult. The nominal capital is £500,000 in £1. 365,007 shares have been taken up, 350,000 of these being issued as fully paid, and upon the remaining 15,007 the full amount has been called. The calls paid amount to £15,003, leaving £4 unpaid. Registered office: 34, Walbrook.

CITY NOTES, REPORTS, MEETINGS, &c.

Pilsen-Joel and General Electric Light Company, Limited.

AN extraordinary general meeting of the shareholders of this company was held at the City Terminus Hotel, Cannon Street, on Thursday afternoon, Sir Rawson W. Rawson, C.B., presiding, for the purpose of considering the resolutions agreed to by the committee of shareholders and the directors, and which were given in our issue of last week.

The Secretary, Mr. E. T. Gregory, having read the notice convening the meeting,

The Chairman said the objects the board had had in view for some time past were to reduce the charge against the company through the amount paid to the vendors, and to reduce the liabilities of the partly-paid shareholders to those holding fully-paid shares. The original bargain with the Union Company was to pay them £15,000 in money and £60,000 in shares, those shares being considered as fully paid up. At present, the partly-paid shareholders had paid £2 10s. per share, which amounted to £70,000, and the charge they had to meet was £130,000. By the proposed scheme the Union Company surrendered its £60,000 worth of shares for the sum of £14,000, and instead of each share yielding to them £5 as they had anticipated, £1 3s. 4d. would be all they would receive—an excellent arrangement for the shareholders in the General Company. The Union Company had met them in a very fair and liberal spirit, and the result would be that the sum for which they would have to provide a dividend out of profits would be reduced from £130,000 to £84,000. That sum would be still further reduced to £56,000 by cancelling £1 of the capital as proposed by the second resolution, and therefore all that the directors would have to do would be to provide for the expenses of the company, and for the payment of dividend on £56,000. There was another advantage of equal importance. There had been hanging over the partly paid shareholders the certainty that if the company is unable to carry on its operations, and should be wound up, they would have to pay up the balance of their shares, and then the present fully paid shareholders would be entitled to their proportion of the sum thus raised, £70,000, before anything would be returned to those who contributed; besides that, the holders of fully-paid shares would be entitled to their share of the liquid assets of the company, and to their share of the value of the patents. In spite of that, the Union Company had consented—looking with fair and reasonable eyes to the relative positions of the two classes—to abandon those claims and to accept the sum of £14,000 in lieu of the £30,000, three-sevenths of the £70,000 unpaid capital to which they were entitled, and all expectations in regard to the assets. That was the result of the negociations with the Union Company; but the committee further proposed, and the directors agreed, that in the interests of the shareholders, and in order to give a marketable value to their shares, it would be desirable to cancel £1 on each share of the £28,000, the present paid-up capital, and also to surrender another £1 of the liability under which they now laboured. At present they were liable to be called upon for £2 10s. per share. It was proposed that that should be reduced to £1 10s., of which 10s. would be paid to the Union Company to carry out the arrangement he had stated. They considered that that £1 might be necessary to ensure profitable results to the company. If they had not a hope of profitable results that money would not be spent, and he would simply say that there was no use whatever in holding that liability over the heads of the shareholders when they trusted to succeed with a smaller sum. After expressing his appreciation of the labours of the committee, the chairman concluded by moving the resolution, which was to authorise the directors to accept the surrender of the 11,530 fully-paid shares held by the vendors, the Union Electric Light and Power Company, and such of the 470 like shares held by the nominees of that company, as could be obtained, paying in lieu thereof a sum not exceeding £1 3s. 4d. per share.

Mr. Whateley seconded the resolution.

Mr. John Taylor, a fully paid shareholder, protested against the scheme because it was not equitable, and said he should vote against the resolutions; if they were carried he should oppose the confirmation, and, if necessary, would carry the case into the House of Lords, so that before the scheme could be carried into effect much time and money would be lost in litigation. He had purchased and fully paid up 250 shares, and he spoke simply for himself and in his own interest. Supposing the scheme were adopted, and the capital eventually consisted of 28,000 shares fully paid at £4 each and 470 fully paid at £5 each, it was evident that, should they be told at any time that the whole capital was lost, that one class would lose more heavily than the other. With respect to the proposed reduction of £1 per share on the amount liable to be called up, that could not with justice be done until the whole 12,000 fully paid shares were cancelled or £1 in cash returned on the 470 shares already having £5 paid, and he was persuaded that no court of equity would approve so long as one shareholder situated as he was objected. Mr. Taylor then moved as an amendment:—"That this meeting stand adjourned for the committee and vendors to meet the holders of the 470 fully paid shares to arrange an equitable readjustment of the scheme to meet the interest of all concerned."

Mr. Hutton seconded.

The Chairman pointed out that the resolution did not affect the holders of shares having £5 paid, because if they liked to keep their shares they would come in for a share of the profits of the company, either immediate or prospective, and were not obliged to accept the proposal unless they liked it.

The amendment was voted for by the proposer and seconder only, and the resolution was carried.

The Chairman then moved the second resolution with respect to reducing the capital, and stated that the object of cancelling £1 on the capital already expended was to enable them at once to divide their profits. If this £28,000 remained as a charge upon their accounts, they could not divide their profits until they refunded the capital. They were never in a better position for making profits than now, and they had a fair prospect of making them. They had opened out a field in Yorkshire and elsewhere in the North, and he could honestly say that he never saw daylight so fairly before him as now.

Mr. Whateley seconded the resolution, which, as also a third, authorising the payment of the costs of the committee, was carried.

Votes of thanks were then accorded to the chairman and the directors, to the committee of shareholders, and to the Union Company, after which the meeting terminated.

Eastern Electric Light and Power Company, Limited.

AN extraordinary general meeting of this company was held at the Cannon Street Hotel on Wednesday, to consider a resolution to wind up voluntarily. Mr. Latimer Clark presided, and there were only a few shareholders present.

The Secretary (Mr. H. Cleland Heywood) having read the notice convening the meeting,

The Chairman said he was sure shareholders would hear with regret that Mr. Noel, the chairman of the company, was absent through illness; he had taken a severe cold, which had affected his lungs, and he had entirely lost his voice. This fact, with the news that had reached the directors within the last hour, might, he thought, lead them to think it advisable that that meeting should be adjourned. Those who were present at the last meeting would remember that Mr. Bull, a shareholder, addressed them and stated that he was about to proceed to India on some private business, and he would look into the affairs of the company and report to the shareholders on his return what his impressions were. A telegram had just been received from him, through Mr. Ashburnham, their representative, in which he advised the shareholders to suspend liquidation until his return, and stated that £1,500 would enable Mr. Ashburnham to pull through for two months. Seeing so small a sum was required to enable them to live, and that Mr. Noel was unable to be present, it was the opinion of the directors that the meeting should be adjourned for about a month to give Mr. Bull time to return, and, if possible, to allow the directors to make some advantageous arrangements in the interests of the company. With respect to the £1,500, he should state that the board had been very actively engaged during the last fortnight or three weeks in endeavouring to meet Mr. Ashburnham's demands of £5,000 and £3,000. The full amount had not been raised, but the sum he originally demanded was so considerably reduced that he thought they would be able to remit sufficient money to prevent their being sold up in India. The £1,500 might be all required to dispose of judgment debts, and the board would make every endeavour to obtain it. A previous telegram from Mr. Bull was to the effect that £3,000 would be required, but there was no need to wind up, and he should protest against that course. The central portion of their works in India was paying its expenses, and he did not think they would be in a worse position a month hence than they were now.

Mr. McArthur, a director, moved the adjournment of the meeting to the 8th of April, and stated that they had property in Bombay sufficient to more than cover their expenses; but certain parties were pressing, and if they took action, and the property were sold by auction, it would probably go at a sacrifice. Whereas, if time were allowed them, they might realise far more than enough to pay their expenses. It was a great misfortune that they had not a little more capital; but for that, this difficulty would not have arisen, and they might have had a very fair prospect of success.

Mr. James Pender seconded the resolution, which was carried unanimously, the meeting then terminating.

The South African Brush Electric Light and Power Company, Limited.

AN extraordinary general meeting of this company was held at the offices, 5, Copthall Buildings, on Monday, Mr. T. Dickson presiding, when the following resolution, passed at a meeting held on the 5th ult., was unanimously confirmed:—"That the capital of the company be reduced from £100,000 to £50,000, the 20,000 shares already issued and constituting the present capital of the company being reduced from £5 each to £2 10s. each."

Australasian Electric Light Company, Limited.—Mr. Henry Hudson (of Messrs. Hudson Bros., Limited) and Mr. John Street (of Messrs. Street & Norton) have joined the local committee in Sydney of this company. Mr. Robert Hammond has consented to act as a consulting shareholder in London, his other engagements having prevented his accepting the office of director.

The West Coast of America Telegraph Company, Limited.—This company announces that telegraphic communication with Valparaiso, Mollendo, Arica, Iquique, Antofagasta, Santiago de Chili, Buenos Ayres, Montevideo, and all telegraph stations in Peru, Chili, the Argentine Republic and Uruguay, is now re-established *viâ* Galveston.

Submarine Telegraph between France and England (Societie Carmichael et Cie).—A dividend for the six months ended 31st December, 1883, at the rate of 17 per cent. per annum, is payable less income-tax, on presentation of the coupons either at the Union Bank of London, 2, Princes Street, E.C.; or to Mr. P. Gil, banker, 6, Boulevard des Capucines, Paris.

Brazilian Submarine Telegraph Company, Limited.—The St. Vincent-Pernambuco section of this company's cable is broken, from five to ten miles from the shore, in about 300 fathoms. The steamship *Lestia* leaves the Thames on Monday next to repair it.

The Eastern Telegraph Company notifies that during the interruption of the Brazilian Company's cable, telegrams will be accepted at reduced rates to go by wire to St. Vincent, thence by first steamer to South America, and onward by telegraph to destination.

Great Northern Telegraph Debentures.—Issue of January, 1883 (Series B).—The interest due 1st March will be paid by Messrs. C. I. Hambro & Son, between the hours of 11 and 2, at 70, Old Broad Street, E.C.

Swan United Electric Light Company, Limited.—The only London office of this company is now at 57, Holborn Viaduct, E.C.

The Indo-European Telegraph Company, Limited, has opened a branch office at 10 and 11, Mincing Lane, connected by special wire with the company's chief office at 18, Old Broad Street.

The Maxim-Weston Electric Company, Limited, has removed from 47, Cannon Street, to 32, Queen Victoria Street.

LATEST QUOTATIONS.

Authorised Issue.	Shares.	Name.	Paid.	Closing Quotations, Mar. 5.	Business Done.
		ELECTRIC LIGHT.			
40,000	10	Anglo-American Brush Co.	8	1⅞ - 2⅛	
		Do. Do.	10	4 - 4¼	
30,000	5	Anstralasian E. L., Power & Storage Co.	2½	..	
24,900	10	British Insulite Co., Ld., "A" Shares.	5	..	
30,000	5	Brush Elec. Lt. & Power Co. (Scotland)	2½	..	
25,000	5	Gt. Western Electric Light & Power Co.	2½	⅛ - ¼	
24,980	5	Hammond Elec. Lt. & Power Sply. Co.	5	1⅛ - 1¼	
40,000	5	Indian & Ori. Electl. Storage Wks. Co.	2	..	
250,000	1	Maxim-Weston Elec. Lt. & Power Co.	1	⅛ - ¼	
100,000	5	Metrop. Brush Electric Lt. & Power Co.	3	..	
40,000	5	Pilsen-Joel & Gen. Elec. Lt. Co.	2½	..	
20,000	5	S. African Brush Elec. Lt. & Power Co.	2½	..	
100,000	5	Swan United Electric Light Co., Ld.	2½	⅛ - ⅜ ⅛	
		TELEGRAPHS.			
1,892,480/.	Stk.	Anglo-American, Limited	100	38¼ - 39¼	38⅛, ¼, ⅛, ⅛
2,553,760/.	Stk.	Do. Pref. } Def. receiving no div. until	100	67½ - 68½	68, 7⅛, 8, 7⅛, 8
2,553,760/.	Stk.	Do. Def. } 6 p. c. paid to Pref.	100	9⅛ - 10	9⅜, ⅛
130,000	10	Brazilian Submarine, Limited	10	9⅛ - 9⅜	9⅜, ⅛, 7/16, ⅛
16,000	10	Cuba, Limited	10	10½ - 10¾	
6,000	10	Do. 10 per cent. Preference	10	17 - 18	
15,000	10	Direct Spanish, Limited	9	4⅛ - 4⅜	
6,000	10	Do. 10 per cent. Preference	10	14½ - 15½	15⅜
65,000	20	Direct United States Cable, Ld., 1877	20	10⅜ - 10⅝	10, ⅜
100,000/.	100	Do. 6 per cent. Deb., repayable 1884	100	100 -103	
380,000	10	Eastern, Limited	10	10⅜ - 11	11, 10⅛, 15/16
70,000	10	Do. 6 per cent. Preference	10	13 - 13½	13, ⅛
232,000/.	100	Do. 6 do. Debs., repayable Oct. 1883	100	..	
280,000/.	100	Do. 5 do. do. Aug. 1887	100	100-103	
200,000/.	100	Do. 5 do. do. Aug. 1899	100	102-106	
250,000	10	Eastern Exten., Australasia & China, L.	10	11 - 11¼	11⅛
320,000/.	100	Do. 6 p. c. Debs., repayable Feb. 1891	100	107 - 110	
500,000/.	100	Do. 5 p. c. (Aus. Gov. Sub.) Deb. 1900	100	102- 105	
140,000/.	100	Do. do. reg., repayable 1900.	100	102 - 105	
100,000/.	100	Do. 5 per cent. Debenture, 1890	100	102 - 105	
550,000/.	100	{ Eastern & South African, Ld., 5 p. c. } { Mort. Deb. Rg. redeemable 1 Jan. 1900 }	100	102- 105	
	100	Do. do. do. To Bearer.	100	102 -105	
22,070	10	German Union Telegraph & Trust, Ld.	10	10 - 10¼	
250,000	10	Globe Telegraph & Trust, Ld.	10	6¼ - 6⅞	6⅞, ⅛
250,000	10	Do. 6 per cent. Preference	10	12½ - 12⅝	12⅜, ⅛, ⅛, ⅜
150,000	10	Great Northern	10	13½ - 13⅝	
100,000/.	100	Do. 5 per cent. Debentures	100	101 -104	
300,000/.	100	Do. 5 per cent. Debentures	100	103 -105	102⅞, 3
81,200	10	India-Rubber, Gutta-Percha, & Tel. Wks.	10	21 - 22	21⅛, ⅛, ¼
100,000	100	Do. 6 per cent. Debs., 1886	100	102 - 105	
18,000	25	Indo-European, Limited	25	30 - 31	30⅞
40,000	10	London Platino-Brazilian, Limited	10	3⅛ - 3⅜	
12,000	10	Mediterranean Extension, Limited	10	1⅛ - 1⅛	
3,200	10	Do. 8 per cent. Preference	10	2 - 4	
10,000	8	Reuter's, Limited	8	9 - 9⅛	
338,225/.	Stk.	Submarine	100	195 -205	195
75,000	1	Do. Scrip	1	1¼ - 1⅜	
4,200	Cert.	Submarine Cables Trust	100	97 -108	93¾
37,350	12	Telegraph Construction and Mainten.	12	33½ - 34½	34
150,000	100	Do. 6 per cent. Bonds, 1884	100	105 -108	
186,750	5	Do. 2nd Bonus Trust Cert.	2½	1½ - 1⅝	
30,000	10	West Coast of America, Limited	10	6 - 6½	6½
150,000/.	100	Do. 8 per cent. Debs.	100	107 -110	
45,791	15	Western and Brazilian, Limited	15	5⅜ - 5⅝	5⅜
24,119	7½	Do. Preferred	7½	4⅛ - 4⅜	
24,119	7½	Do. Deferred	7½	1⅛ - 1⅛	
280,000/.	100	Do. 6 p. c.. Debs. "A" 1910	100	103 -106	
250,000/.	100	Do. 6 p. c. Mort. Deb. B. '80, red. Feb. 1910	100	94 -101	
1,500	$1,000	Western Union 7 p. c. 1 Mort. (Bg.) Bds.	$1,000	122 -126	
1,030,000/.	100	Do. 6 per cent. Sterling Bonds	100	100 -104	
88,321	10	West India and Panama, Limited	10	⅛ - 1⅛	
34,563	10	Do. 6 per cent. 1st Preference	10	7 - 7⅛	7⅛
4,669	10	Do. 6 do. 2nd do.	10	5 - 5½	
		TELEPHONES.			
224,850	1	Con. Telc. & Mainten., L., Nos. to 154,165	1	5/16 - 7/16	
225,000	1	Oriental Tele. Co., Nos. 80,001 to 300,000	½	⅛ - ¼	
100,000	5	United Telephone Co.	5	7⅛ - 8	7⅛, ⅛
20,000	5	Do. New, issued 2 p.m.	2	..	

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of February was 3,482, estimated to produce £3,000, against 4,380 messages, producing £4,036 in the corresponding month of last year. The receipts for the month of November, estimated at £2,550, realised £2,380.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of February are €1,567, against €1,472 in the corresponding period of last year.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

An ordinary general meeting of this society was held on Thursday, February 28th, Professor W. G. ADAMS, F.R.S., President, in the chair. The minutes of the last ordinary general meeting having been read and confirmed, and the list of new, and proposed new, members announced, the statement of the accounts for the year 1883 was submitted. Allusion was also made to the loss which the electrical world had sustained through the death of Le Comte Th. du Moncel.

A paper was then read by Mr. W. M. MORDEY, Associate, on "Some Prejudicial Actions in Dynamo Machines." In the conversion of energy a certain amount of loss is unavoidable, but as the causes of this loss come to be more understood, its amount can be greatly reduced. The actual rendering of dynamo machines is not quite so great as is generally stated, owing to the dimensions of the electrical units not being equal to their absolute value, the difference amounting to rather more than 1 per cent. In dynamo machines there were losses which took place in the conductors and in the iron; the cause of the loss in the latter was due to the generation of so-called Foucault currents. With reference to this name, Mr. Mordey considered that the term "Eddy" currents would be more appropriate, and he so names them in his paper. The eddy currents not only tended to heat the iron of the machines, but also tended to demagnetize it, and thus to lessen the efficiency. The heating took place when the circuit was open as well as when it was closed, a fact which was only comparatively recently noticed. By arranging the shunt of the machine and altering the lead of the brushes, the heating effect could be reduced. The effect of the currents in question varied with the resistance of the iron used, but it was not practicable to reduce the detrimental effect by any modification of this resistance; the disuse of iron, also, was impracticable, more especially as the eddy currents did not only circulate in the armature of the machine, but also in the pole pieces. Owing to the existence of the eddy currents, the efficiency of the machine as represented by the resistance of the circuit and the electromotive force between the terminals of the machine was not quite correct. The rise of temperature which takes place in the coils of the machine causes considerable waste, amounting to 30 per cent. in the armature. If permanent field magnets could be substituted for electro magnets there would of course be a reduction of waste, but at present it was not possible to do this. The use of conductors of a square section for winding the machines would be an improvement, but it was difficult to properly insulate such wire. It would be practicable, however, to place a naked copper wire between the space left between the turns of the wire of round section, and thus to some extent to obtain an increased effect. In estimating the efficiency of machines, it should never be forgotten that the circumstances under which they are required to be used ought to be carefully taken into consideration.

In the discussion which followed the reading of Mr. Mordey's paper, Mr. R. E. CROMPTON said that, although Mr. Mordey had pointed out in his paper the various defects which existed in dynamo machines, he had not shown how they could be remedied. He doubted whether the heating of the armature of a dynamo machine was actually due to the "eddy" currents, for the dividing up of the iron of the armature, so as to prevent such currents circulating, did not prevent heating; the latter was probably due to a molecular action in the iron, which would best be diminished by careful annealing. He did not consider that the size of the field magnets was an unimportant question, as on board ships economy of space was important. The loss of 30 per cent. due to the heating of the armature was not, he thought, a loss of great importance, as it represented a very small percentage of the total efficiency when the resistance of the armature was small compared with the external resistances. As good *mechanical* construction was of great importance in machines, it was inevitable that a certain amount of efficiency should be sacrificed. He thought that wire of a square section would be very troublesome to wind properly. With reference to the proper kind of iron to use for dynamo machines, he would point out that it was now exceedingly difficult to obtain charcoal iron owing to the fact that the use of mild steel was so extensive; a great deal of the so-called charcoal iron was actually *coke* iron, which was not a proper material for the purpose required.

Mr. J. E. H. GORDON said that the results of some experiments he had made in slitting the cores of the magnets for dynamos proved that the "eddy" current had very little to do with the heating. He found that heating increased considerably after the machines stopped working, as stated by Mr. Mordey, but he thought this was only due to the gradual creeping out of the heat. The use of an extra naked wire, as suggested, he calculated would only add 1¼ per cent. to the amount of metal which could be wound in a given space, a per centage which he thought was hardly worth the trouble.

Prof. FORBES said that as much as 12 per cent. was lost by using round instead of square wire. He thought that Wiedemann's method of insulating a wire by a thin coat of sulphate of lead might be adopted with advantage. He would like to ask Mr. Mordey why copper tubes were used in the magnets of the Brush machines; were they for the purpose of steadying the current?

Prof. AYRTON said that the inconstancy of the current in so-called constant current machines was probably a source of considerable loss; that these fluctuations occurred could be proved by placing the primary wire of an induction coil in circuit with the dynamo and then joining the secondary coil to an electrical dynamometer; if the current was unsteady, a deflection on the dynamometer would be obtained. One cause of unsteadiness was due to the departure from the original form of Gramme and the adoption of the Paccinotti type with projecting pieces of iron on the armature. The unsteadiness could be considerably reduced by using large field-magnets. He would point out that the great sparking which occurred at the brushes of the machines when charging accumulators, was entirely due to this unsteadiness, the latter being aggravated by the back electromotive force of the accumulators.

Mr. MORDEY, in replying, said that the 30 per cent. loss he had referred to as taking place in the armature was really serious, as it meant a corresponding reduction in the life of the machine owing to the heating; with reference to this loss and also Mr. Gordon's remark on the small per centage of improvement which would be effected by the addition of the naked wire to the winding of the machines, he would point out that every little improvement, although small in itself, still increased the general total. He thought that no actual proof had been brought forward to show that the heating was molecular and not due to "eddy" currents. With reference to Professor Forbes' query as to the use of copper tubes in Brush machines, these were, as surmised, for the purpose of steadying the current.

A note was then read by Prof. FORBES on "Breguet's telephone," and also on a "Compensated Resistance," the latter being a combination of a carbon with a metal resistance.

The meeting then adjourned.

Physical Society, February 23rd, 1884.

Prof. F. GUTHRIE, President, in the chair.

New Members.—Mr. E. F. J. Love, Mr. James Grundy, Rev. F. J. Smith, Mr. F. R. Bawley.

Prof. SILVANUS P. THOMPSON read a paper on "A new method of making resistance coils." This consisted in cutting off a piece of the wire of which the coil is to be made, long enough to give a resistance some 2 per cent. higher than is actually required. From the formula

$$\text{Shunt} = \frac{R\,r}{R - r}$$

(where R is the rough resistance, and r the final resistance), the value of a wire wherewith to shunt the first piece in order to give the resistance required is found. A length of wire giving this resistance (or rather about 2 per cent. more) is then cut off and soldered as a shunt to the first piece. Practice shows that this method is very quick and accurate. It is useful for shunts under 10 ohms.

Prof. Thompson also described a new form of meter-bridge devised by him. The wire is 2 meters long, and there are two wires, one of a resistance about ¼ ohm, the other 8·21 ohms. Contact is made with one or other by a sliding contact, with vernier attached. This arrangement is more convenient than the single wire meter-bridge, and allows of higher resistances being measured. A special switch-board, with an arrangement of mercury cups, avoids the necessity of transposing the coils in Foster's method, this being effected by shifting the contact links in the mercury cups.

Mr. R. J. GLAZEBROOK, F.R.S., explained a cam or axle key, devised by Mr. Shaw, to effect the contacts necessary to transpose the coils by a single movement. He pointed out that a certain pressure was necessary to make good contact with mercury. The ordinary way of making coils was to double the wire, cut the bight, bare the ends there, and solder a piece of copper across them, which could be shifted until the resistance was got.

Prof. G. C. FOSTER said that the copper links in mercury cups should rest on the copper.

Prof. FOSTER read a paper by himself and Mr. Pryor on the difference of potential required to give sparks in air. Let v = this difference of potential, l = length of spark in centimetres, their experiments gave (approximately) $v = 102\ l + 7{\cdot}07$. Tables and curves of the sparking distances, potentials, and electric forces in the experiments were given. The results were got with brass balls, 1·35 centimetres in diameter, a frictional machine, and a Foster absolute electrometer. When l = ·142 the electric force giving a spark was 154·76; l = ·284, the electric force was 133·35, or less than at a shorter distance; l = 497, the electric force was 131·66; l = ·9 the electric force was 138·57, that is, it began to rise again.

Prof. G. FORBES made a communication on a magnetised chronometer watch. The watch slowed several minutes a day. He found the rate to vary with the position of the watch with respect to the north cardinal point, and also in a vertical plan. The bar of the balance was magnetised and some screw nails. He traced the variation of rate to magnetisation of the spring, the bar, and screws. The fact that it varied with position suggested that a magnetised ship's chronometer might be made which would integrate the course, and give a mean course. Messrs. E. Dent & Co. had fitted a gold spring and a platinum iridium balance to the chronometer, and rendered it non-magnetisable.

NEW PATENTS—1884.

3999. "Filaments for glow or incandescent lamps." J. SWINBURNE. Dated February 27.

4000. "Filaments for glow or incandescent lamps." J. SWINBURNE. Dated February 27.

4025. Electrical conductors for telephonic or other purposes." E. T. TRUMAN. Dated February 27.

4032. "Galvanic battery." H. FAIRFAX. Dated February 27. (*Complete.*)

4042. "Enabling electric arc lamps to be used advantageously in parallel circuit with one another, or with incandescent lamps." J. E. H. GORDON. Dated February 27.

4050. "Arc lamp." J. A. BOWEN. Dated February 28.

4060. "Printing telegraphs." W. P. THOMPSON. (Communicated by H. Van Hoevenbergh.) Dated February 28. (*Complete.*)

4070. "Electric governors for dynamo machines and engines." J. SWINBURNE. Dated February 28.

4088. "Working and controlling electrically railway signals and points. E. TYER. Dated February 28.

4095. "Supporting or conducting electrical wires from place to place." T. O. WINDSOR. Dated February 28.

4107. "Compound magnets." S. H. PARKES. Dated February 28.

4112. "Commutators or collectors of electrical machines." J. H. JOHNSON. (Communicated by Z. T. Gramme.) Dated February 28.

4121. "Incandescent or glow lamps." J. SWINBURNE. Dated February 29.

4158. "Thermo-electric piles or batteries." H. H. LAKE. (Communicated by D. Lantensack, A. Kohn and O. Laske.) Dated February 29.

4167. "Contact arms between telpher trains and suspended conductors parallel to the suspended road." F. JENKIN. Dated February 29.

4208. "Manufacture of certain parts of incandescent electric lamps." C. H. BENTON, H. H. GRUBBLE. Dated March 1.

4226. "Electric circuit closers for land service. J. T. BUCKNILL. Dated March 1.

4270. "Removable key switch applicable to fittings for electrical lamps and other purposes." G. RICHARDSON, W. RAWORTH. Dated March 3.

4271. "Manufacture of incandescent or glow lamps." J. SWINBURNE. Dated February 28.

4296. "Microphones." A. J. BOULT. (Communicated by K. S. Dembinski.) Dated March 3. (*Complete.*)

4302. "Dynamo-electric machines." R. E. B. CROMPTON. Dated March 3.

4309. "Electric time pieces." W. P. THOMPSON. (Communicated by F. Baumann.) Dated March 4.

4327. "Improved means for transmitting sound by means of electricity, and of reproducing the same at a distant station." F. V. STEAD, E. R. HEDGMAN. Dated March 4.

4346. "Insulating materials or compounds for electrical conductors." W. R. LAKE. (Communicated by T. S. Leigh.) Dated March 4. (*Complete.*)

4365. "Lead armoured electric cables and mandrels for manufacturing the same." R. S. WARING. Dated March 4. (*Complete.*)

4366. "Lead armoured electric cables and mandrels for manufacturing the same." R. S. WARING. Dated March 4. *Complete.*

4367. "Electric cables and mandrels for manufacturing the same." R. S. WARING. Dated March 4. (*Complete.*)

4368. "Electric cables and mandrels for manufacturing the same." R. S. WARING. Dated March 4. (*Complete.*)

4369. "Making branches or loops, and repairing defects in lead armoured electric cables. R. S. WARING. Dated March 4. (*Complete.*)

4371. "Mandrels for manufacturing lead armoured cables." R. S. WARING. Dated March 4. (*Complete.*)

4382. "Galvanic batteries and other purposes." C. J. D. OPPERMANN. Dated March 4.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1883.

2872. "Manufacture of electric arc lamps." H. J. ALLISON. (Communicated from abroad by W. Baxter, jun., of America.) Dated June 8. 6d. Relates to the manufacture of air tight electric lamps, and consists in certain improvements in the construction of the casing in which the regulator is enclosed, in the means used for securing the glass globe to the frame of the lamp, and in the trunk or tubular connection between the casing and globe. The objects of the invention are to gain access more readily to the regulator and carbons; to adjust the latter without removing the globe or detaching any part of the apparatus, and to prevent the access of the gases of combustion to the regulator.

2857. "Systems of generation and distribution of electricity for light, heat, and power." T. J. HANDFORD. (Communicated from abroad by T. A. Edison, of America.) Dated June 7. 10d. Relates to such systems of distribution of electric energy for illumination, heat, and motive power, for improvements in which the inventor obtained Letters Patent, dated the 28th December, 1882, No. 6199; that is to a system in which a divided source of energy is employed supplying translating devices, arranged in multiple series, one or more compensating conductors being provided, whereby the said translating devices are made independently controllable, and the system is divided into two or more parts.

2922. "Electric meters." J. E. H. GORDON. Dated June 12. 6d. Relates to improved meters for registering the quantity of electricity, or of electric energy used for lighting or other purposes. In many existing meters the portion of the apparatus moved by the electricity has to move the registering apparatus. The necessary friction of the latter introduces errors. In the apparatus which is the subject of the present invention the part actuated by the electricity moves freely, and a motion actuated by clockwork moves the counter at short intervals through a distance depending on the position of the part moved by the electricity. Either the whole or a known part of current to be recorded passes through the coil of a galvanometer, or other apparatus for measuring electric current or energy. The axis carrying the pointer of the galvanometer is horizontal. Fixed on the axis, and moving with it is a disc of thin brass or other light rigid material. This disc is cut to an elliptical or other curved shape, the curve being determined by experiment so that the vertical radius has its maximum length, when there is no deflection of the galvanometer, and gets less as the deflection increases, so that (neglecting small corrections) there is an equal decrease of radius for the increase of deflection corresponding to each unit increase of current, or of energy. A clock is fixed near the galvanometer, and on its hour axis or other axis is a notched wheel which allows an arm to drop at intervals of say ten minutes. This arm in its zero position is held just clear of the upper edge of the disc when there is no current. When dropped it falls till it is stopped by the edge of the disc. If there is no current, it falls practically no distance, but if a current is passing the arm falls a greater or less distance, according to the amount of deflection. The edge of the disc is preferably notched, or cut into saw teeth, or otherwise roughened, so that the arm falling on the sloping edge shall not push the disc round and alter the deflection. Immediately after the fall the clock raises the arm to its zero position. As it rises a catch on it engages a ratchet wheel and moves a counter consisting, for instance, of a train of wheels like those of a gas meter. The amount indicated depends on the distance which the arm had fallen, *i. e.*, on the deflection.

2938. "Telephonic apparatus." J. M. BETTS. Dated June 13. 2d. Within a casing or framework is arranged a curved or bent spring or rod, carrying a bar or core of iron or steel on which is a coil of insulated wire, the core being either a permanent magnet, or the core and coil together constitute an electro-magnet, and opposite the one pole of the core is either a second electro-magnet or simply an armature. The spring is made to press or to pull with its end or ends, or with any part thereof, against a disc or diaphragm, which is attached to the casing in any manner that will allow it to vibrate when a person speaks in close contiguity therewith. On the vibration of the disc in consequence of such speech, the spring is slightly bent, and is thereby caused to move the electro-magnet to or from the armature or second electro-magnet, and such motion of the electro-magnet will cause a correspondently fluctuating electric current to be produced in the coil, which is transmitted, through the line wire. Or conversely, a fluctuating current passing from the distant station through the coil, will cause the electro-magnet to approach to or recede from the armature or second electro-magnet, and, in thus bending the spring, will produce corresponding vibrations in the disc or diaphragm. (*Provisional only.*)

2949. "Insulating wires or electrical conductors for dynamo-electrical machines, &c." J. H. JOHNSON. (Communicated from La Société A. Chertemps et Cie., of Paris.) Dated June 13. 4d. Relates to improvements in the preparation of non-conducting compounds for coating and insulating wires or electrical conductors. According to this invention, inorganic compounds which are bad conductors of electricity and are not liable to be decomposed by the action of heat are employed to form a non-conducting coating for the wires of electrical generators. For this purpose a liquid preparation is employed capable of depositing a salt or other like product from which the water may be subsequently expelled by evaporation, the presence of water in the coating being liable to impair the insulation, or to dissolve the materials. In the preparation of this coating oxygenised compounds or salts of silicon or its analogues, boron, aluminium or magnesium are preferably employed; silicate of potash, may also be employed for this purpose, but it is found that the presence of soda potash or other analogous bases hinders the evaporation of the water in combination. It is therefore preferable to employ the oxides of the metals hereinbefore referred to—*videlicit*, silica, boric acid, alumina, or mag-

nesia, by preference in a gelatinous condition obtained in a manner well known to chemists.

2993. "Galvanic elements." F. WIRTH. (A communication from C. Pabst, of Germany.) Dated June 15. 4d. Consists in the employment as the electrolytic liquid of the aqueous solutions of the chlorides of such metals of which two corresponding to the oxide and protoxide exist in chromium compounds, soluble in water. The higher chloride is reduced by the metallic electrode to the lower degree of oxidation, and again becomes oxidised to to the higher degree by the absorption of oxygen from the atmosphere. The electrolytic liquid preferred is the aqueous solution of iron chloride or tin chloride, the metallic electrode suitable for which is made of tin or iron. The element may be composed in either of the following ways:—1. Carbon.—Tin in a ten per cent. iron chloride solution; 2. Carbon.—Iron in an eight per cent. iron chloride solution, containing four per cent. of tin chloride.

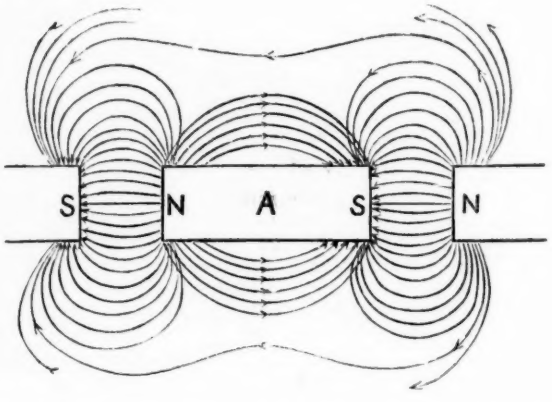
2804. "Apparatus for generating, regulating, measuring, and distributing electric currents and electric energy." A. GRAY and T. GRAY. Dated June 6. 1s. 4d. Relates to improvements in apparatus for generating, regulating, measuring and distributing electric currents and electric energy.

2850. "Manufacture of electric incandescent lamps, and appliances for the regulation of electric currents therefor, &c." W. J. L. HAMILTON. Dated June 7. 8d. The inventor makes the filament or burner of bogwood, such as that from fir, oak, or yew, the latter preferred as much superior but not often found. The material having been cut up into thin sheets, or the filament having been cut to the required length and section, is soaked in boiling water or other suitable liquid. The filament is then bent into the required form while hot and pliable. It is then impregnated throughout with tetrachloride of platinum (Pt Cl 4), and whilst wet exposed to the fumes of chloride of ammonia (Am Cl) in a state of sublimation. The double salt, 2 Am Cl + Pt Cl 4, is thus formed in the pores of the filament. The filament is next treated with lime water, or with the solution of a salt (but not the chloride) of calcium, barium strontium or magnesium until the pores are as nearly as possible filled up with such salt.

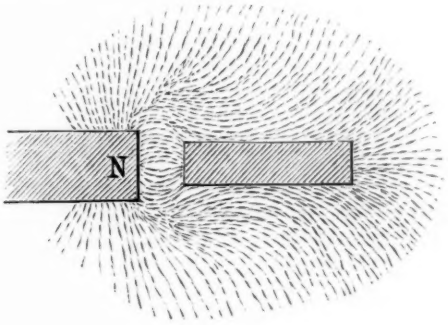
CORRESPONDENCE.

The Theory of the Gramme Machine.

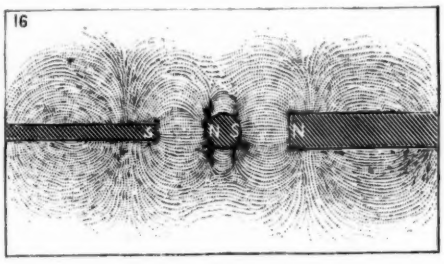
The discussion between M. Wolffers and myself on the actual distribution of lines of force in a Gramme machine, has narrowed itself down till it can fortunately be decided by the aid of a piece of cardboard and some iron filings. I should not have trespassed upon your space again however, but for the fact that in your issue of the 23rd ult. M. Wolffers makes use of observations of a personal nature, which it is impossible for me to overlook. Perhaps this gentleman's evident loss of temper is the result of a feeling that he had not quite made out so good a case as he could wish. In order to settle the point at issue, and to make it clear that I have not—as M. Wolffers mildly expresses it—"been guilty of a gross perversion of facts," I will ask you to be good enough to re-insert his diagram given in your paper of the 9th ult.



To show that the lines of force in a simple magnetic field of this sort, consisting of two poles with a short bar of iron between them, is not as represented in the diagram, I gave a reference to Fig. 7, plate IV, of Vol. III., Faraday's *Experimental Researches*. A copy of this figure is given below, and although only one pole was used, the arrangement is substantially the same as that of M. Wolffers, but the curves will be seen to be exactly opposite to his, *i.e.*, they bend *in* towards the iron, and of course bear no resemblance to the extraordinary formation invented by him.

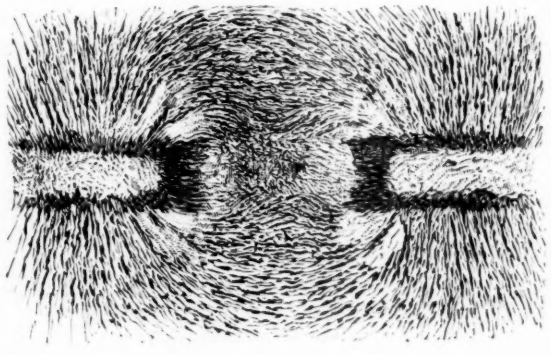


But M. Wolffers entirely ignores this proof of the inaccuracy of his views, and reproduces Fig. 16, Plate III., given below (*instead of Fig. 7, Plate IV*),



an entirely different figure; being, in fact, as explained by Faraday, the formation produced by a small permanent magnet in the field produced by two large magnetic poles—a very different one to that produced by a piece of iron in the same field.

As an example of the actual arrangement found by opposite magnetic poles having a short bar of iron between them, I give below a figure engraved from the actual filings:



The curves were formed on a sheet of cardboard previously coated with gum, and dried, a jet of steam then completing the process and making the figure permanent.

By comparing this figure with M. Wolffers' diagram it will be seen that the latter was not the result of experiment.

W. M. Mordey.

Motors for Electrical Machines.

In your impression of the 1st inst., I notice that you review a work by T. Schwartze on "The Motors for Electrical Machines," and as his ideas on the utilisation of wind and water power so entirely coincide with mine, as set forth in my letter, published in the

ELECTRICAL REVIEW, October 27th, 1883, I write again to draw attention to the subject, in the hope that it may be taken up in earnest in some practical manner in this country.

Douglas M. Forsyth.
Commander R.N.

Ryde, *4th March*, 1884.

Reviews.

Your reviewer in noticing my book in last week's TELEGRAPHIC JOURNAL, states that "as a pupil of Sir William Thomson, the author is no doubt biassed in favour of that gentleman's graded galvanometers, and consequently we have very full descriptions of these instruments." And lower down: "If, however, we are to depend—as the inventor practically intends we should—on the regulating magnets remaining of constant magnetic intensity, we should be extremely sorry to guarantee the accuracy of our measurements," and so on to similar effect.

As I do not consider this criticism just, I beg leave to say in reply, first, that I disclaim any such bias. It is stated in the introduction to my book that its main object is to give an account, both theoretical and practical, of electric measurements in terms of absolute units. Accordingly, after giving an account of the foundation of absolute magnetic and electric units, and of the derivation of practical units, of methods of determining the horizontal conponent of the earth's magnetic force, and the magnetic moments of magnets, and of the theory and use of a standard galvanometer, I came to the application of all this to the graduation of galvanometers for practical work. To make definite what I had to say on this subject, I took Sir William Thomson's graded galvanometers as an example, and after describing them, showed how their constants are determined, and how their indications may be verified or corrected by the user himself. It was my opinion that the methods and details of graduation described being those used in actual practical cases, might be of service to experimenters graduating or using other instruments, and not the less so that the methods are in some respects particular rather than general, and I adhere to this opinion.

Next, as to the statement of your reviewer that the inventor of the graded galvanometers intends that the constancy of the "regulating magnets" should be relied on, it seems hardly necessary to say that Sir William Thomson has not, and never had, any such intention. On the contrary, he distinctly states in the instructions sent out with the instruments that the intensity of the field which the magnet gives at the needles should be determined from time to time, and gives warning that precautions are to be taken to prevent accidental demagnetisation of the magnet. Apart from this explicit statement, the fact that the date of the determination of intensity is marked on the magnet, *is* a clear indication that variation of the magnetic intensity may be expected. Also, throughout all I have written regarding the graded galvanometers, it has been my aim to facilitate their verification or correction from time to time, and I have been careful to describe various methods of determining the horizontal force at the needles given by the magnets.

One very important point in the plan of these instruments must not be overlooked. Their graduation proper is entirely independent both of the value of the earth's horizontal force, and of the constant of the magnet given with them, and is performed for a magnetic field at the needles of horizontal intensity equal to one C.G.S. unit. Thus, the graduation does not sensibly vary, and supplies an absolute standard which enables the magnetic intensity of the field produced at the needles by the magnet to be accurately determined by means of a standard cell, by electrolysis, or otherwise. Thus, as the local horizontal force (which is small in comparison with that due to the magnet) is generally approximately known, the instruments are, *pace* your reviewer, "absolute" instruments, the indications of which are sufficiently accurate for all practical purposes. The magnet does, as was, of course, anticipated from the first, fall off in strength for some time, but an easy test made at intervals, or when accidental demagnetisation has taken place, is enough to correct for any change, and the graded galvanometers are, when ordinary care is taken in their use, perfectly reliable.

A. Gray.

The Physical Laboratory,
The University, Glasgow,
March 4th, 1884.

On the Best Proportions of the Coils of Galvanometers.

Galvanometers are susceptible of having certain proportions given their coils which make them electrically the most efficient. These proportions in any particular description of galvanometer may be determined either by experiments, or in some cases by calculations.

If the volume of the coil is kept constant while the number of turns or the strength of the current is varied, then the action of the coil upon the needle will vary as the current strength and the length of the wire; but the length of the wire will be proportional to the square root of its resistance, and therefore the action upon the needle will vary as the current strength and the square root of the resistance; that is, to the square root of the energy expended in the coil. By winding the galvanometer with wires of different diameters (using always the same constant volume of wire) the resistance of the galvanometer may be made such that it is suitable for any particular current strength. But there is also a particular shape of coil and volume of wire which produces the greatest action upon the needle with a constant expenditure of energy in the coil. There is a certain proportion of external diameter to (internal diameter and length of coil), and also a certain proportion of length of coil to internal diameter of coil which gives a maximum action upon the needle, with a constant expenditure of energy. These proportions may be ascertained experimentally by the method by which the proportions of an electro-magnet may be found (described in the REVIEW, 31st January, 1884); but the dimensions of galvanometers can (unlike those of electro-magnet coils) be calculated with tolerable accuracy in particular cases. Thus, in the tangent galvanometer, let the outside diameter of the coil be x times the inside diameter, then the action of the coil upon the needle would be proportional to the (density of the current) $\times \int_1^x \frac{1}{x}\,dx$., but when the amount of energy expended in the coil was constant, the currents density would vary as the reciprocal of the square root of the volume of wire that is as $\frac{1}{\sqrt{x^2-1}}$ the action of the coil on the needle would therefore equal

$$\frac{\int_1^x \frac{1}{x}\,dx.}{\sqrt{x^2-1}} = \frac{\log x}{\sqrt{x^2-1}}$$

and this becomes a maximum when $x = 2{\cdot}23$.

In determining the most suitable volume of wire to put upon a reflecting galvanometer, the methods of calculation and experiment may be with advantage combined, thus several coils may be tried that have different volumes, and as nearly as possible the same shape as the curve given on (p. 322, Clerk-Maxwell, vol. 2.) That coil will have its $\frac{\text{deflection}}{\sqrt{\text{volume of coil}}}$ the greatest when a constant amount of energy is expended in the coil.

It is worthy of notice that any divergence from the most efficient proportions of a coil does not produce nearly as great a divergence in the efficiency of the galvanometer. Thus, if in the tangent galvanometer the outside diameter was decreased from 2·23 to $1\frac{1}{2}$, the

outside diameter being 1, then the efficiency of the galvanometer would only be reduced about $\frac{1}{30}$; and even if the outside diameter were made $1\frac{1}{10}$, the efficiency would only be reduced to about $\frac{1}{2}$.

W. Moon.

Bell's Telephone Patents in England.

In my letter on this subject published in the REVIEW of 1st inst., it must be apparent to the reader that the first paragraph is in direct contradiction to the rest of the letter. I intended to correct the *implication* that the opinion I expressed that "under no circumstances could the avoidance of a foreign patent affect the validity of a patent granted in Great Britain for the same invention," *referred to patents granted under the new law only*. The rest of my remarks show that that opinion applied to patents granted under the Act of 1852.

Your correspondent "Receptor," can find answers to his questions by referring to the "Patents, Designs, and Trade Marks Act, 1883," sections 22, 27, and 45.

This last section is as follows: "Every patent granted before the commencement of this Act, or on an application then pending, shall remain *unaffected* by the provisions of this Act relating to 'Patents binding the Crown;'" (27) and to "Compulsory Licenses;" (22) "in all other respects this Act shall extend to all patents granted before the commencement of this Act, or an application then pending."

Under the new Act "an application for a patent must contain a declaration that the applicant is the true and first inventor." These words have led many persons to think that the practice heretofore used of persons taking out a patent by correspondence from a person abroad was prohibited. The form D of *Letters Patent* in the Act contains these words: "If the said patentee is not the first and true inventor thereof *within this realm*." These words seem to be in contradiction to the declaration required to be made by the applicant for a patent. This seeming contradiction is reconciled by referring to the "Statute of Monopolies" of 21, James I., 1623, wherein is the following sentence: "Inventor means the person who first introduces the invention into Great Britain."

W. C. Barney.

March 3rd, 1884.

When I penned my letter on the above subject which appeared in the REVIEW of the 23rd ult., although I thought that Mr. Barney might take exception to some of my remarks, I did not expect that his rejoinder would disclose what I must, with the greatest respect, call such gross ignorance of patent law as he betrays in his letter inserted in this week's issue. It is a pity Mr. Barney did not in the present instance follow his own rule, and not "express an opinion on any point of law without having consulted the books thereon," as although that gentleman tells us he is aware of the existence of Section 25 of the Patent Law Amendment Act of 1852, he clearly has never read it, or he would not say as he does, "The case is entirely different when the foreign patent has been declared void by a judicial decision, or has become forfeited by non-compliance with the laws of the foreign country."

For the information of those of your readers who are interested in the subject, I may mention that the exact words of Section 25 of the Patent Law Amendment Act of 1852 in referring to a British patent for an invention for which a patent had been previously obtained in a foreign country are, that the British patent "shall cease, and be void immediately upon the expiration *or other determination* of the term during which the patent, or like privilege obtained in such foreign country, shall continue in force." Now I always understood the word "*determination*" when used in the sense plainly indicated by the context in this section of the Act, to mean "*putting an end to*." I therefore contend that under the old Act of 1852, if a United States patent were annulled, the posterior British patent for the same invention would *ipso facto* become void. If Mr. Barney has still any doubt as to the correctness of my construction of the Act, let him refer to Goodeve's "Abstract of Patent Cases," p. 113, where it is reported that in the case of Dawe *v.* Eley, it having been put in evidence that a French patent of one Schneider, of prior date to the British patent in question, had been annulled by the French tribunals, Vice-Chancellor Wood said: "The French patent of Schneider, and all rights under it, are gone, and if it is identical with the English patent, it follows as a necessary result that the English patent is gone also. It comes then simply to the consideration of the two patents. . . . . Now upon the question of identity I have no doubt. No difference can possibly be drawn between the two things. That being so it does appear to me that the injunction terminates here from the moment that the French court decides that the French patent has come to an end." Mr. Barney, however, says that if a court were to annul a British patent on that ground, "the court would decide against the well-established law that a prior publication to affect the validity of a British patent must be a publication within the United Kingdom." Now is that gentleman really so obtuse that he cannot distinguish between things that differ, so that he is unable to see that there are two distinct grounds of invalidity, viz., (1) want of novelty within the realm; and (2) the determination of a prior privilege abroad? If Mr. Barney still thinks that these two causes of invalidity are conflicting, I would respectfully remind him that we must take the laws as we find them, and not by attempting to reconcile what to us is paradoxical, put our own gloss and erroneous interpretation upon them.

After what I have stated I need scarcely make any observation on the two paragraphs of Mr. Barney's letter, which follow my last quotation from it given above. I cannot but regret, however, that a person who evidently possesses so little real knowledge of the law on the subject, should have given his opinion with so much self-assertion as Mr. B. does when he says, "I hold it to be good law under the Act of 1852, that a decision in a foreign country avoiding a patent granted there, could not in any way impair the validity of an English patent obtained subsequent to the foreign patent"—a conclusion which is as pregnant with error as it is remarkable for the boldness with which it is put forth.

As stated, however, in my last letter, the law is now altered, and British patents are not affected by the lapse of a prior foreign patent for the same invention. This brings me to the subject of "Receptor's" letter, in answering the first paragraph of which I think I cannot do better than quote Sub-sections 2 and 3 of Section 45 of the Act of 1883;

"45. (2) Every patent granted before the commencement of this Act, or on an application then pending, shall remain unaffected by the provisions of this Act relating to patents binding the Crown and to *compulsory licenses*."

"(3) In *all other respects* (including the amount and time of payment of fees) this Act shall extend to all patents granted before the commencement of this Act, or on applications then pending in substitution for such enactments as would have applied thereto if this Act had not been passed."

With reference to "Receptor's" second inquiry, I am sorry I am unable to give a satisfactory answer thereto in the absence of full information as to the date or dates and contents of the Bell patent or patents in the United States. I apprehend, however, that little good will result from discussing what would have been the effect upon the Bell patent in England, in the case of the avoidance of the American patents had the new Act not been passed, as it is perfectly clear to me that in the event of the American Bell patent being declared null and void now, this circumstance will in no wise affect the validity of the Bell patent in England.

Thos. J. Handford.

42, Southampton Buildings,
March 4th.

[We beg to call Mr. Handford's attention to the preceding letter.—EDS. ELEC. REV.]